BELL TELEPHONE QUARTERLY

VOL. XVI JANUARY, 1937

THE AMERICAN COMMUNICATION COMPANIES AND NATIONAL PREPAREDNESS

THE EVOLUTION OF THE CRYSTAL WAVE FILTER

MAKING NEIGHBORS OF NATIONS

EQUIPPING THE TELEPHONE FLEET

A NORTHWEST WINTER—AND THE TELEPHONE

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

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The American Communication Companies and National Preparedness*

IN accepting the invitation of the Secretary of War and the officers of the Army Industrial College to appear here and speak on the subject of The American Communication Companies and National Preparedness, it seems to me that a brief word as to my qualifications is in order.

With one short interruption during the period of the World War, when I served as Director of the Council of National Defense and of the Advisory Commission, practically all of my active life since graduating from college has been concerned with the problems of electrical communication and with the building up of an organization, the Bell System, designed to provide the people of the United States with the best, most comprehensive and most economical system of electrical communication which physical science and human organization make possible.

Specifically, my experience has covered not only the problems of the directing and operating units of the Bell System but likewise the problems of the Western Electric Company, which in our Bell System organization is responsible for the manufacture or supply of the physical things which our research and development organization, Bell Telephone Laboratories, develops and designs.

Even the interruption in this life work occasioned by the incidents of my World War duties was not really a break in the continuity of my connection with the problems of electrical communication, since many of the vital questions with which the Council had to deal were directly or indirectly concerned

* An address before the Army Industrial College, Washington, D. C., December 10, 1936.

with matters of electrical communication, either for the combat forces in Europe or at home or with the civilian activities which were their source.

While I am not myself a trained scientist or engineer, and so hardly competent to express a worth-while opinion on highly technical details, my more than thirty years of association with the problems and operations of the multitude of material instrumentalities on which the whole art and service of electrical communication is based has given me, I think, a proper appreciation of the major problems involved in the question we are here considering.

The Fundamental Problems Stated

As I see it, the fundamental problems concerned with electrical communication in connection with the national defense are not alone those which, when the emergency of war arises, will insure to the combat forces of the nation an adequate supply of communication material and an adequate personnel of men trained in its use and with an ability rapidly to instruct a larger number of other men to equal efficiency.

Of equal or even greater importance are two other problems which in my judgment must never be lost sight of if the primary objective of the military forces, victory, is to be achieved. One of these is that the material and personnel required initially for the combat forces (and which will, unaided, have to withstand the first shocks) must be arranged for in advance so as to be almost instantaneously available without producing an equally instantaneous disruption of the civilian service of communication.

The second problem which must not be lost sight of is that the demands of the combat forces on the civilian establishment, whether for material or personnel, must not so cripple the latter as to leave it incapable of providing for a suddenly enlarged and newly distributed demand for communication within the underlying service of supply.

We know from our experience during the World War, not only that the demands for electrical communication, both by telephone and telegraph, peak up enormously on the first impact of war, but, what is even more disconcerting, that the distribution of traffic undergoes violent change and that telephone and telegraph routes which under normal peace-time conditions are little used become overnight main arteries of traffic demand. Further, experience in the emergencies of both war and peace shows that the too rapid introduction of untrained personnel into the operating organization of an electrical communication system tends automatically to degrade the ability of the communication network to provide satisfactory service. Moreover, beyond a certain point further introduction of such personnel tends to accelerate the downward spiral.

Having stated the major problems as I see them, let me say now a word about my view as to our potential ability to cope with them.

Meeting the Problems

As I see it, the United States above all other nations is most favored in this direction. While its normal telephone and telegraph facilities are operated by independent agencies rather than being concentrated within a single governmental administration, as is the case in most foreign countries, they can readily be made to function, if needed, as a single integrated whole. In addition, they have the advantage of certain stimuli of private initiative, which seems to be denied to political administrations whatever the form of government. Added to this is the fact that the Bell System, with its all-inclusive services of research and development, manufacture and operation, is not only by far the largest communication organization in the world, but is likewise, I think, generally recognized throughout the world as the most advanced in its development of electrical communication.

If in what follows I seem to dwell largely on the Bell System and on telephony, it is partly because of this predominant position of the Bell System in the whole art of electrical communication, and partly because the technical problems of telephony are in general more difficult than the technical problems of telegraphy and, when solved satisfactorily, carry in that solution generally the automatic solution of a host of telegraph problems.

With this preface related to the general aspects of our subject, let me now turn to a brief historical review and to some of what seem to me the more important details of the problem.

Lessons from the World War

What we might term the modern rôle in warfare of the electrical transmission of intelligence, particularly by telephone, is of very recent inception. It dates from 1917 and 1918, i.e., from the closing chapters of the World War. It therefore vied with chemical warfare and certain forms of mechanized warfare in the rapidity of its development. The military forces which went into the conflict in 1914 were equipped with simple forms of wire and radio telegraph and with wire telephones of a kind, but no radio telephones. Those that emerged from it, and especially the American Expeditionary Forces, had at their command a far-flung communication network involving not only thousands of miles of wire and cable together with fully developed telephone and telegraph exchanges and systems of the most modern sort, but also radio telephones with which flying aircraft could for the first time keep in touch with one another and with the ground, and with which naval ships could communicate by spoken word across hundreds of miles of water.

The rapid ascension of the telephone, both wire and radio, in military affairs was the direct consequence of certain epoch-making developments in the telephone art itself. Science contributed certain devices like the repeater, the vacuum tube

amplifier, the modulator and the electric wave filter, which were entirely new in principle, with the result that about 1914 or 1915 it became possible for the first time to say that the telephone was in a fair way to overcome all terrestrial distances. January, 1915, saw the opening of the first transcontinental telephone line linking New York and San Francisco, and in the summer and fall of the same year speech was successfully transmitted by radio from Arlington, Virginia, to Honolulu and across the Atlantic to Paris.

Work with the Army and the Navy

These two American accomplishments were quick to receive recognition from the United States Army and Navy. It was January, 1916, sixteen months prior to this country's entrance into the War, that we of the Bell System were asked to assist the Army and Navy communication people in determining how our new discoveries and developments could be adapted to their needs. It was in that month that J. J. Carty (later General Carty), then Chief Engineer of the American Telephone and Telegraph Company, read an important and confidential paper before the Army War College. This was at the request of General McComb, President of the College, and the paper was soon repeated before the Naval War College. Two months later, and again with the intention of demonstrating the military significance of some of the new developments for which the Telephone Company had been responsible, Mr. Carty arranged a demonstration in the course of which connections were established between the New Willard Hotel in Washington, where a distinguished audience was assembled, and the following points in sequence:

	Miles Distant from Washington
Seattle, Washington	3,700
Ottawa, Canada	780
El Paso, Texas	2,600
Jacksonville, Florida	820
San Francisco, California	3,400

The connection to El Paso brought in General Pershing, who was then stationed on the Mexican Border.

This demonstration was followed shortly by a request from Mr. Daniels, Secretary of the Navy, for a test of radio telephony between ships and between ship and shore. During the test, the Secretary from his office in Washington held frequent conversations with the Commander of the Battleship NEW HAMPSHIRE while it maneuvered off Hampton Roads. So pleased was the Navy with this demonstration that studies were at once authorized and urgently prosecuted for the purpose of adapting radio telephony to naval maneuvers generally. Similar developments were instituted for the purpose of perfecting radio telephone apparatus that would be applicable to army maneuvers and to aviation.

It was during the same year, 1916, that those familiar with the vital changes which the telephone art was undergoing began to realize the essentially new land line communication problems which the maintaining and direction of a huge American Army overseas would involve. To picture the situation then existing, I cannot do better than quote some post-war testimony of General Carty before the Committee on Military Affairs of the House of Representatives:

"There had been preparations made for war in the European terrain for forty years. When the war broke it was not possible for any of the European nations to provide a communication system adequate for the conduct of the war. It remained for the Signal Corps of the U. S. Army in nine months to construct a long distance telegraph and telephone system which the Governments of Europe had failed to do in forty years. We did that in nine months. There was a wire from Rome to Paris a great deal bigger than the wire we talk on from Washington to San Francisco, but they could not talk over it. . . .

"The Signal Corps built a system extending from Marseilles on the south to LeHavre on the north, and across the Channel to London, and equipped a line on to Liverpool; on the west their line went as far as Brest, and on the east as far as Germany. We were able to talk all over

the Continent. That gives you an idea of some of the work done by methods absolutely unknown to any of the nations engaged in the combat."

I do not need to remind this audience that the Signal Corps had behind it and at its disposal the facilities of the American telephone and telegraph industry. From its scientific laboratories came the new developments which surprised the armies of Europe. On the one hand, it produced the multifarious equipment—the telephone switchboards, cable and open-wire lines, loading coils and repeaters; on the other hand, it provided the trained personnel which the installation, maintenance and operation of such new equipment required. At the outbreak of the War, as I remember it, the Signal Corps staff of the Army numbered about 1,600; this the Bell System as their part of a coöperative undertaking matched three for one, supplying in the space of a few months some 4,500 engineers, installers and operators. The telegraph and independent telephone companies supplied a proportionally large number of trained men. As indicating the effectiveness of this assistance, I cannot do better than quote from a letter dated January 16, 1918, and written by General Edgar Russel, then Chief Signal Officer of the American Expeditionary Forces, to Mr. Carty:

" Let me again express my great appreciation of the splendid work you have done for us. Without your selection and organization of the officers and men you have contributed to this cause, I am sure our work would have been tremendously hampered. As it is, we are well ahead of the game, and the Signal Corps is receiving warm commendations from the Commander-in-Chief and the Line and Staff Departments."

We should note, however, that General Russel's letter sees only one of two very important aspects of the then existing situation. The supplying, in a minimum of time, of these 4,500 highly skilled individuals for military service had been arranged for with due regard to the point which I mentioned earlier as one of the fundamentals, namely, that of leaving essentially unhampered and uncrippled the ability of the nor-

mal service to cope with the problems of unprecedented demand and the training of new personnel.

It has been suggested that you would be interested in having me outline today my opinion as to whether the American communication industry is now in position to carry a war-time load. My answer is that we are better prepared in every way, should another emergency arise. Not only are we fortified by the experience gained during the World War, but since the Armistice the communication art has never for a moment ceased its progress. Engineering facilities and operating techniques of both telephony and telegraphy, by wire and radio, have advanced enormously in the past decade and a half. Many improved forms of equipment and many services which during the World War were unknown are now in current use. Some of these are distinctly attractive from the standpoint of military operations. Some, on the other hand, appear to present quite unappraised potentialities. I think it may be of interest if I comment briefly upon the more significant aspects of this post-war evolution.

Overseas Radio and Cable Channels

During the World War, communication between this country and our military forces in Europe took place largely through a few submarine telegraph cables. Two or three of these cables actually were cut and the fear that others would go in the same manner was responsible for a very prolonged state of anxiety on the part of those responsible for maintaining transatlantic channels of communication. You may not know it, but the situation appeared so grave at one time that a special committee of distinguished engineers was organized by the State Department, with the coöperation of the War and Navy Departments, to develop and introduce immediately methods of operation which would very greatly increase the traffic carrying capacity of existing submarine cables.

This contrasts rather forcefully with the extent to which radio channels have today established the telephone and the telegraph as mediums of international communication. It is now possible from any telephone in the United States to reach practically every other country in the world; 66 nations or dominions is, I believe, the figure given by the latest count, or 93 per cent of all the telephones in the world. The significance of such a world-wide telephone network is incalculable in times of peace; in war, it may be equally vital in speeding urgent messages. At the present time, we witness every day the successful completion of scores of telephone conversations between this country and the various countries of Europe, South America and the Orient. Just by way of illustrating the progress in overseas telephone service since its inauguration in 1927, I might refer to a demonstration conversation held successfully in April, 1935, over a wire and radio circuit which completely encircled the earth. The speakers, of whom I was one, were in adjoining offices in New York City.

Moreover, overseas telegraphy by means of radio has, in the intervening nineteen years, made vast strides, there being direct channels now to practically all important countries. In regard to these, there has been a notable clarification of the situation since 1917. At that time, certain of the most important American radio stations were German-owned and had either to be closed down or to undergo a change of operating staff, with resulting delay and restriction of service. Since that time, control has been vested in American hands, thus simplifying war-time operating restrictions. Moreover, the equipment employed has improved in a variety of fundamental respects. The old mechanical alternators have given place to modern vacuum tube equipment for continuous wave signaling. Also, high speed automatic sending and receiving apparatus has entered the radio telegraph field as well as that of wire telegraphy.

Any consideration of the war-time use of radio channels, particularly those of high power for overseas communication, raises the question of secrecy and possible interruptions of service. The so-called privacy systems which we employ on our radio telephone circuits are very effective indeed so far as peace-time requirements are concerned. Like most telegraph ciphers, however, they are not unbreakable, a fact to which during a military campaign it would be necessary to give due weight. Moreover, all forms of radio are more or less vulnerable to intentional interference but I shall not presume to the extent of discussing this matter, with which doubtless you are already thoroughly familiar.

In passing, there is, however, one point connected with the fallibilities of radio transmission to which I would direct your attention. The vast progress in radio development, the obvious flexibility of its operation, and the glamor attendant upon its achievements, may have, I fear, tended to mask some of its as yet not overcome weaknesses, and to an extent have caused us to relegate the submarine telegraph cable to a too ancient category of outworn agencies. Added to the points of weakness of radio just mentioned must be a realization that the long swing periods of changing radio transmission which we attribute to sun spot disturbances are as yet little understood and we have no assurance as to exactly what will happen to all of our radio transmissions during the next period of maximum solar activity. If the results of this activity should exceed our present surmises and if perchance this maximum period should come at a time of emergency, we might find ourselves seriously crippled in our electrical communications if we place too much dependence on the one means which radio provides us.

From the standpoint, therefore, of both secrecy and continuity of service, the submarine cable is one of the mainstays of world communication, and hence it is very important to record here that although the cable is one of the oldest devices

for electrical transmission of intelligence, the post-war epoch has witnessed a complete revolution in its design. The most modern type of cable now employed has approximately five times the message-carrying capacity of the pre-war non-loaded type. The first of these high speed telegraph cables was laid across the Atlantic in 1924 and others in various localities have since been placed in service. These cables are characterized by a continuous loading of the magnetic alloy, permalloy, and it is their reduced attenuation for signal currents which accounts for their high traffic capacity. Since the last of these high speed transatlantic cables was laid, shortly before the beginning of the depression, continued research and development work has indicated that cables with traffic capacity far in excess of that of the most modern now in operation can be produced. To the extent that cable communications are fundamental in time of war, the existence of these new circuits represents an important reinforcement of our international telegraph channels.

Land Line Facilities

The growth of our national telephone land line facilities since the World War has, if anything, been more prolific though perhaps less spectacular, than that of the overseas channels. To portray this domestic progress, I shall quote certain data which we keep for our own information and by means of which we attempt to see our telephone service as the user sees it. The average number of minutes required to establish a long distance connection dropped from 13.6 minutes in 1920 to 7.5 minutes in 1925 and again to 1.4 minutes in 1935. Correlatively, the percentage of long distance calls handled with the calling party remaining at the telephone rose from a negligible percentage in 1920 to 15 per cent in 1925 and again to 92 per cent in 1935. I shall not trouble you with even a cursory account of the increase and improvements in the American telephone plant and the changes in operating practices which

explain the progress revealed by these data. Underlying them there has been, however, a notable growth in American telephone facilities and this fact is in itself so fundamental to our discussion today that I will, in passing, call your attention to the following figures.

In United States	1920	1936
No. of telephones	13,329,400	18,450,000
No. of miles of wire in storm-proof toll cables	1,700,000	12,800,000
No. of miles of open toll wire	2,660,000	3,100,000

While similar figures for the other leading nations are not so vital from the standpoint of today's theme, they are of interest as signifying the world-wide recognition now accorded telephony. Thus Europe is today overlaid with a toll cable network containing some 5,500,000 miles of telephone wire, all having sprung into existence within the past ten years. The creation of this network marks what might almost be called a new era in telephone communication in Europe, and shows that the nations across the Atlantic have definitely ascended out of the primitive state described by General Carty before the House of Representatives, in which they had heavy copper circuits that were virtually useless for telephone purposes. Interconnecting most important European centers we now find this cable network—which in all respects is of the most modern type, and whose design, installation and operation are indicative of international coöperation on the part of the various telephone authorities.

Conference Telephone Service

Perhaps some of you will recall one of the items of the National Defense Day program in Washington on September 12, 1924. For that occasion, General Pershing was provided with a single telephone connection which included 23 other centers; he spoke from Washington with General Bullard in New York, General Hale in Chicago, General Duncan in Omaha and General Morton in San Francisco, and their words

in turn were carried to Washington over transcontinental telephone lines and broadcast by 19 radio broadcasting stations in various parts of the country. I mention this occasion and the part which the telephone played in it because it was a forerunner of what we now call conference telephony. A few weeks ago, on the occasion of the celebration of the twenty-fifth anniversary of the Telephone Pioneers Association, as many as 265 banquet and assembly halls, scattered over the extent of the United States and Canada, were linked together on a conference circuit. In this case loud speaking receivers were provided at each hall and the arrangement was unquestionably the most extensive conference circuit ever established.

This form of call has within the past few years become a regular feature of American telephone service. From a telephone in this room, for instance, I could, through the regular traffic channels, place a call for several other parties simultaneously either within our local area or at remote points of the country, and within a reasonably short space of time be assured of a connection whereby I could be speaking to all of these points at the same time. They, in turn, could answer and their remarks would be heard by all of the other participants to the connection. I need not stress the importance of this type of service before a gathering of this sort. It can provide a rapid and yet personal contact between various headquarters—for instance, between Washington and the headquarters of various Corps Areas, or between various key points within an Area. The service is extremely flexible and is nation-wide in its extent. I might add that within recent months some of the European nations have undertaken to offer a corresponding service, and I understand that with them it now traverses national boundaries in certain instances.

Switched Telegraph Service

Turning next to the telegraph service, we encounter new developments which in their flexibility are similar to those long

characterizing the telephone service. Within recent years, there has grown up a considerable group of subscribers to a switched telegraph service, whereby any subscriber can at any time call any other subscriber and upon completion of the connection, transmit his message himself. This service involves printing telegraph machines so that as the message is transmitted it becomes available to both sender and receiver in the form of typewritten copy. Our latest figures show that the service now numbers over 10,000 subscribers who, for the most part, are business houses, factories, banks, etc. For military purposes, where secrecy is involved, automatic ciphering and deciphering printing telegraph machines could be used as readily as those regularly employed.

The average time of connection in the switched telegraph service is quite comparable with that in toll telephone service, being in the neighborhood of 1.3 minutes. The distance bridged by the average connection our traffic data show to be 420 miles. The average number of words per message is 200. I cite these figures merely to show that although this is a new service, we are nevertheless dealing with one which has attractive potentialities, and which in war-time might be of great assistance in coördinating national effort.

Telephotography

Another development which some claim will be of value, especially for the transmission of maps to guide troop movements, is the electrical transmission of pictures. As you are all familiar with the quality of results obtainable with present-day equipment, I feel sure there is no need for me to enter upon a discussion of the subject.

Other Telegraph Developments

The instrumentality employed in the switched telegraph service, namely the printing telegraph machine, has in recent

years been widely adopted by the commercial telegraph companies, both wire and radio, for handling private messages. It was not so long ago that the bulk of this telegraph traffic was transmitted and received by means of the key and Morse sounder. Today, probably 95 per cent of the traffic is handled by printers. Telegraphists who can read the Morse code are greatly reduced in numbers and their places have been taken by those familiar with a typewriter-like keyboard. This trend is one which has a certain significance from the standpoint of military communications. The weight and size of the printer do not lend it to field maneuvers. In an active campaign, it would be necessary to rely largely upon the trained ear of those who can read the telegraph codes.

But, fortunately, as one supply of trained telegraphists has dwindled, another source has sprung into existence. This new source comprises the small army of short-wave radio amateurs, estimated in this country to number perhaps 45,000, whose pastime is to communicate with one another through their low-powered transmitters. The results of a recent survey[1] indicate that in this body of radio amateurs there is probably an adequate supply of telegraphists for Army requirements, and I understand that through the Army amateur radio system a nucleus for meeting mobilization requirements is being defined.

Broadcasting

Turning next to broadcasting, we come to one of the most important of the post-war communication developments but one whose influence at a time of national emergency, although considerable, probably cannot be forecast with certainty. Upon the one hand, it permits the broadside circulation of propaganda, both friendly and enemy, although because of the geographical position of the United States the menace of subversive propaganda reaching us via broadcasting is probably of less moment than in the case of many other countries. How

[1] Report of the Hough-Bickelhaupt Board, 1934.

it can best be used to maintain national morale and assist in securing prompt and intelligent coöperation on the part of our vast population is a matter the details of which I will not attempt to picture. It seems to lend itself equally to the aims of the political party in control and to those of rebellious groups. In the latter category stands the recently attempted *coup d'etat* in Austria, wherein the revolutionists attempted to seize the broadcasting station simultaneously with their entrance into the Chancellery. In the former is the general strike which paralyzed England for a few days in 1926. I have heard it related that during that brief crisis when there were no newspapers, broadcasting did much to sustain the public morale and that one of the most reassuring messages which came over the radio was the sound of Big Ben striking the hour. This was in 1926, just after broadcasting had been born. Today, with its immensely greater coverage, its influence is doubtless proportionately larger. Reports from Russia tell of widespread use of radio broadcast for all sorts of purposes.

Television and the Coaxial Cable

While discussing the question of new equipment and services, such developments as television and the so-called coaxial cable deserve a word in passing. It is perhaps difficult at this stage of its development to assign to television any particular military value. The coaxial cable, on the other hand, because of its extremely simple physical structure, might find important uses behind the lines as a source of backbone communication channels, especially if quick methods of burying it underground prove practicable.

For military purposes wide band carrier systems which provide twelve or more independent telephone channels on each pair of ordinary telephone cable wires might prove of far more interest even than the wider band systems of the coaxial cable structure. In carrier on ordinary cable pairs, the four-wire

system of operation is required; that is, the twelve west-bound transmissions are carried on one pair and the corresponding twelve east-bound transmissions on another pair shielded from the first. Thus two small shielded cable each containing, say, six pairs of wires, can provide for as many as seventy-two simultaneous two-way telephone conversations.

Communication Needs in Case of Mobilization

Leaving this brief review of the more significant telephone and telegraph developments since the World War, we turn to the procurement problems which are destined to spring into existence should a grave national emergency arise. Due to the highly specialized character of the electrical communication art, both in regard to the diversity of equipment which it demands and the extended knowledge and training which its personnel must possess, these procurement problems are of special moment. At this time and place, and granting the existence of an emergency, it is not necessary to stress the elaborate requirements of the Army and Navy both for communication material and personnel. When these communication requirements expand suddenly, as they would were another war-time emergency to arise, they must be met promptly but not at the expense of the equally urgent requirements of the business and industrial world for the same effective communication service to which they have become accustomed in peace.

It is extremely fortunate that, in the handling of these difficult problems, the communication industries, which must be looked upon as the principal source of both trained personnel and specialized equipment, have been accorded sympathetic and intelligent coöperation by the Army and Navy, to the end that plans are now available whereby the necessary transposition of man-power and equipment could be made with what appears to be a minimum of dislocation in the established services.

Although many of you here are more familiar than I with these plans, it is my understanding that the estimated mobilization requirements of the U. S. Signal Corps for initial and subsequent mobilization will total around 6,000 men, including about 500 communication specialists required for the Corps Area Service Commands.

As to the procurement of 6,000 specialists, this must, as already mentioned, be accomplished smoothly, rapidly and without any derangement of the established services. It calls for the most efficient coöperation between the Corps Area Commands and communication companies in each Corps Area, to effect which it has been suggested that the Signal Corps establish a specialized recruiting group to be made up of Reserve Officers selected from the personnel of the four large communication companies. Should an emergency become imminent, these recruiting officers would be given the necessary instructions by the respective Corps Area Signal Officers, upon receipt of which the recruiting officers would immediately work out with their respective companies plans for selecting the personnel required.

Other essential plans have been laid with regard to the supply of communication material—wire, cable, switchboards, instruments, repeaters, radio apparatus, etc. Thus, the Western Electric Company, the manufacturing unit in the Bell System, knows quite clearly what the Signal Corps would call upon it for in case an emergency arose. Manufacturing schedules have been discussed together with delivery programs which satisfy both parties. These of course are coördinated with the probable civilian demands so as again to eliminate as far as possible any disturbing effects of a war upon the vital communication industry.

Similarly, for the Army cantonments which would spring into existence, contracts have been drawn up between the various communication companies and the Army and Navy which

merely require signatures in order to set into motion a vast machinery of shipment and installation.

Special War-Time Co-ordination

While it was realized well in advance of the actual declaration of war in 1917 that mobilization of the nation's resources would require skillful coöperation, there unfortunately was not time enough to develop anything like the detailed schedule which we now have. It is not to be expected, however, that plans such as those to which I have just referred have been so skillfully prepared as to meet every emergency. Unforeseen situations are bound to arise, and to cope with these some purely war-time organization will be necessary, whose functions would be the expeditious coördination of civilian and military effort and the reconciliation of conflicting demands. It is conceivable, for example, that even with the far more extended telephone and telegraph plant which we have today, an emergency of such magnitude might arise as to call for a rationing of communication supplies and service. This need did definitely arise in 1917 and a coöperative committee on telegraphs and telephones under the chairmanship of Theodore N. Vail, at that time President of the American Telephone and Telegraph Company, established the necessary routines. In connection with this committee, it is significant that it came into existence prior to our entry into the World War and by the beginning of 1918, almost a year before the War closed, it had discharged its functions so satisfactorily that it became from then on inactive.

As to what emergency war-time organization ought to be established should another crisis arise, my view is that we should not attempt too detailed a forecast. Emergencies and threats of war are of so many different types, some minor and some major, that to plan far in advance the organizational machine required to cope with the situation seems of rather dubious value. We know from past experience that even in

the case of a decidedly major emergency, such machinery can be created and caused to function in a surprisingly short time. My suggestion, therefore, would be to let our steps in this direction be dictated by the nature of the emergency, remembering that the primary function of the machinery is not to issue orders, but to bring together the national problems as they arise and the experts who are best qualified to attempt solutions. This was the chief rôle played by the Council of National Defense and its Advisory Commission together with their many coöperative organizations, such as the National Research Council.

As Director of the Council of National Defense and the Advisory Commission, I had an excellent opportunity of seeing how effectively such an arrangement can function. From the outset the purpose of the Council and the subordinate committees of the Council was to offer a channel through which the voluntary efforts of American industrial and professional life could be focused. The story of the way in which the members of these committees, practically all of them serving without compensation, rallied to aid in the common cause and the extent of the practical accomplishment of their voluntary service has probably not been equaled anywhere. The general spirit underlying these original committees was fundamentally that of business organizing itself in aid of the Government. The natural processes of administrative evolution gradually eliminated the old, large committee system in the case of the industrial committees and substituted for it a closely knit scheme of sections under the general head of the War Industries Board, in which each section head had general authority over all dealings with the industry with which he was particularly familiar. At the same time, the industries of the country rapidly organized to assist the Government in carrying on the War and created representative war-service committees of their own, thus simplifying and strengthening the method of coöperation of business with the Government.

The ways in which problems were brought before the Council and the method adopted in dealing with them varied greatly. At times they were discussed first by the Advisory Commission and brought before the Council with a recommendation. At other times they were brought to the attention of the Council through Government departments or other governmental organizations or through private citizens. The Council's general practice in handling questions which it did not itself act upon directly usually took one of three forms. Where the question apparently lay within the discretion of one of the executive departments or of an already existing Government agency, the Council referred the matter under discussion to this agency for executive action with or without a recommendation. In this way, questions of overlapping jurisdiction could frequently be settled. Where no agency for handling the matter existed and where some further investigation seemed advisable before a decision could be reached, the Council frequently referred the matter to the Advisory Commission for investigation or to one of the subordinate committees before action. Where the question was one of particular urgency and unusual authority was needed for its solution, the Council, after a thorough discussion, at times referred the matter directly to the President for final determination, usually with a recommendation.

From the first, there was not only a willingness but an affirmative desire to allocate to other agencies of the Government activities initiated by the Council and carried along by it to mature performance. The Council at all times resisted tendencies to cling to activities which could best be directed elsewhere. This policy was consistently maintained and was in harmony with one of the Council's prime functions, namely, to act as a sort of proving ground for problems dealing with public and governmental welfare specifically in respect of national defense. To cite a few examples as to how this policy worked out, the Committee on Transportation grew in due course into the Railroad Administration; out of the Gen-

eral Munitions Board came the War Industries Board; and out of the Committee on Coal Production grew the Fuel Administration. The Council was in no sense a fixed institution, but continued in a process of evolution rapid enough to keep abreast of the changing current of the times and yet conservative enough to prevent confusion through lack of proper coordination and control. It was therefore constantly ready to fill in the gaps and to assist regular departments of the Government in their efforts to expand and carry the new and huge burdens put up to them not only by the War but also by the aftermath of the War.

With this brief historical review of the functioning of the Council of National Defense, the picture which I have wanted to draw for you is complete. On the one hand, we have noted well-planned and well-understood, though quiescent, routines which are ready—for instant adoption in case of an emergency—to control the flow of communication services, of materials and of personnel both into the fighting services and into urgent civilian channels. Behind these routines, and without which they would be entirely ineffectual, stands the entire communication industry with its operating, its engineering and its research facilities. I have outlined very briefly the recent achievements of this industry in those respects in which they merit your consideration. Moreover, measured by such standards as you military experts have seen fit to exact, I understand that our capacity in all important respects appears adequate to a national emergency. Finally, to supplement the routines which, however carefully planned, can never cope with all the shifting variables of a prolonged campaign, we are provided from recent history with the example of a successfully functioning Council of National Defense to analyze, to recommend, and generally to coördinate the almost fabulous technical talent of the country. Our position, therefore, as to communications appears to be one of adequate preparedness.

WALTER S. GIFFORD

The Evolution of the Crystal Wave Filter*

ONE of the most impressive features of organized industrial research is the evolutionary character it assumes when carried on over a long period of time. New inventions and discoveries breed others. An invention made ten years or more ago to fill a particular need at the time finds application today in situations that could not possibly have been foreseen when the original research was undertaken. Almost any important piece of telephone apparatus used in modern long-distance telephony would serve to illustrate this point. On examination, one would find in it contributions from researches conducted for purposes very remote from the needs which the apparatus now meets.

The crystal wave filter, employed at the terminals of new broad-band telephone transmission systems, is a convenient and fairly typical piece of apparatus to examine and discuss in this regard. It is not spectacular in appearance, and, in this respect, is characteristic of many of the more important and less publicized products of the laboratory. In external appearance it is nothing more than a metal box measuring about 3 x 5 x 16 inches, and designed to mount on central-office frames in accordance with our regular telephone practice. Within the box are a few apparently very simple pieces of apparatus almost as unimpressive as the box itself. No part of the assembly would attract particular attention from the casual observer, and yet it will reveal on careful study an interesting story of research.

A wave filter, of which the crystal filter under discussion is a special type, is a device that allows alternating current of certain frequencies to pass readily through it, and opposes a high

* Presented at a meeting of the Institute of Physics in New York, N. Y., October 30, 1936.

impedance to currents at all other frequencies. Wave filters find many uses in modern telephony. In this instance, the filter is part of a broad-band telephone transmission system: that is, a system which transmits a large number of conversations simultaneously over a single telephone line. The line may be a pair of open wires on poles, a pair of small wires inside a lead-covered cable, or it may be a coaxial line consisting of a copper pipe which carries a centrally disposed insulated wire. This latter type of line is of special interest at the moment, since a first practical trial of it is now being made. Figure 2 shows the construction of the coaxial cable recently installed between New York City and Philadelphia. This cable contains two coaxial lines, one to carry speech in each direction, and each capable of carrying several hundred independent speech channels.

The transmission of several conversations simultaneously over a single circuit, which in recent years has become quite commonplace, is itself a remarkable achievement of communication research. It is accomplished by transforming currents of the voice range, the region from about 250 to 3,000 cycles, into currents of higher frequencies. A different frequency band is allotted to each of the conversations transmitted, just as different frequency bands are allotted to different programs in radio broadcast transmission. Not only does the same circuit serve to transmit a large number of conversations at different frequencies, but the same amplifier or repeater can serve for all speech channels, with great resultant economy.

With this type of transmission, known as "carrier transmission," the message carrying capacity of a circuit is determined by the width of the frequency band that the line and its associated apparatus are capable of transmitting effectively. If the available band width of the coaxial line is 1,000,000 cycles, for example, and if a frequency band 4,000 cycles wide is allotted to each speech channel, 250 independent telephone conversations can be conducted over two of these coaxial pipes.

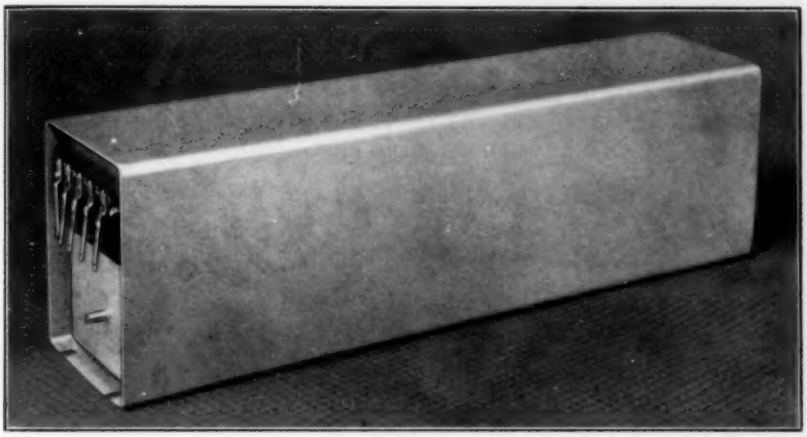


FIG. 1. IN THE CRYSTAL WAVE FILTER FOR BROAD-BAND TELEPHONY, AN AUSTERELY SIMPLE EXTERIOR COVERS A MOST INTERESTING COMBINATION OF RESEARCH PRODUCTS ORIGINATING IN DIVERSE FIELDS.

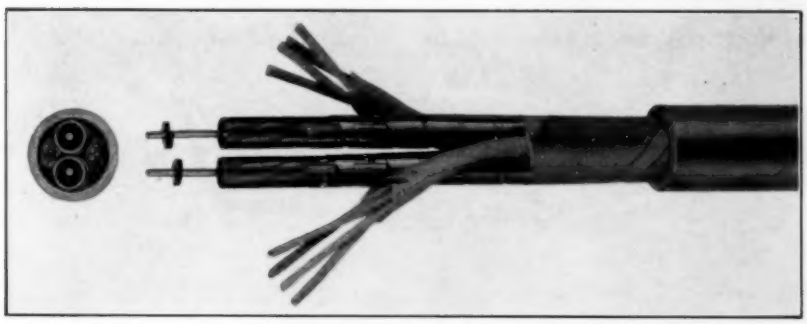


FIG. 2. A SAMPLE OF THE COAXIAL CABLE USED ON THE EXPERIMENTAL CIRCUIT BETWEEN NEW YORK AND PHILADELPHIA.

Crystal wave filters are used at each end of such a circuit—one for each speech channel transmitted in each direction. At the entering end, the filter serves to limit the transformed speech frequencies to those which fall within the assigned band, thus assuring that none gets into other bands to interfere with the speech in other channels. At the outgoing end, the filter serves to select a band of frequencies appropriate to it, and to guide the speech within that band to apparatus that returns it to its original form by relocating the frequency components in their normal positions.

To cover the entire range of frequencies that such a coaxial line can transmit would appear to require 250 filters at each terminal, each designed for a particular band of frequencies. In the interest of economy, however, only 12 different designs of terminal filters are used. These provide twelve 4,000-cycle channels, extending from 60,000 to 108,000 cycles, and each of these 48,000 cycle bands is then treated as a unit, and by a second step of modulation is relocated in its appropriate position on the frequency scale.

Filters play a very important part in the economy of broad-band telephone systems. This is partly because so many of them must be used—four for each two-way conversation—which puts a premium on low cost and physical compactness. But what is fully as important is frequency compactness, which determines the width of band that must be allotted to a speech channel. Because of the sharp cut-off of the crystal wave filter, it is practicable and economical to space the speech channels only 4,000 cycles apart.

If we removed the cover from one of these crystal filters, we should find a very simple assembly, consisting of four quartz plates, four metal boxes containing inductance coils wound on toroidal cores of compressed powdered permalloy, two other metal boxes containing mica condensers, and eight tiny variable air condensers for the fine adjustments. Any of the essential parts of this filter would serve to illustrate the evolutionary

character of development. Let us examine in this regard first the network itself, second the crystal, third the combination of the network with the crystal, and finally the coil. In each case we shall see evidence of contributions from many diverse directions.

To find the beginnings of the evolutionary train of thought which produced the network, we must go back more than thirty years to the time when Dr. G. A. Campbell, then of the American Telephone and Telegraph Company, was studying the possibilities of improving long-distance telephone transmission by loading, i.e., by inserting inductance coils in series with the line at regular intervals. Campbell did not stop with determining what inductance the coils should have and how they should be spaced, but went further and computed the characteristics of such a line for frequencies both within and beyond the range of those used in telephony. He discovered that the coil-loaded line, which transmitted telephone currents more efficiently because of inductance added by the coils, transmitted high frequency currents less efficiently because the inductance, instead of being distributed uniformly, was concentrated at the points where coils were inserted. The transition from improved transmission at low frequencies to impaired transmission at high frequencies was very striking. The loaded line was said to have a definite cut-off frequency, which was a function of inductance of the coils and their spacing along the line.

The loaded line is now looked upon as a low-pass filter, the loading coils providing series inductance and the line wires shunt capacitance. Campbell was inspired by his discovery to study the general case of a reiterative ladder type network in which the reactances of rungs and side arms of the ladder were generalized. Two specific forms of the ladder type network are shown schematically in Figure 3. One is a low-pass and the other a band-pass filter. Within the frequency limits of the pass band, the filter transmits currents without attenuation, but outside of the limits, currents are rapidly attenuated.

Important variations of this network were later derived by K. S. Johnson, G. C. Reier, O. J. Zobel, and others, which made it possible to make combinations of filters to meet almost any practical requirements of band width and of terminating impedance, as well as to avoid reflections of waves at filter terminals.

Campbell later made another great advance in network theory when he derived the lattice type structure, shown in Figure 4. This criss-cross network is a much more flexible tool than

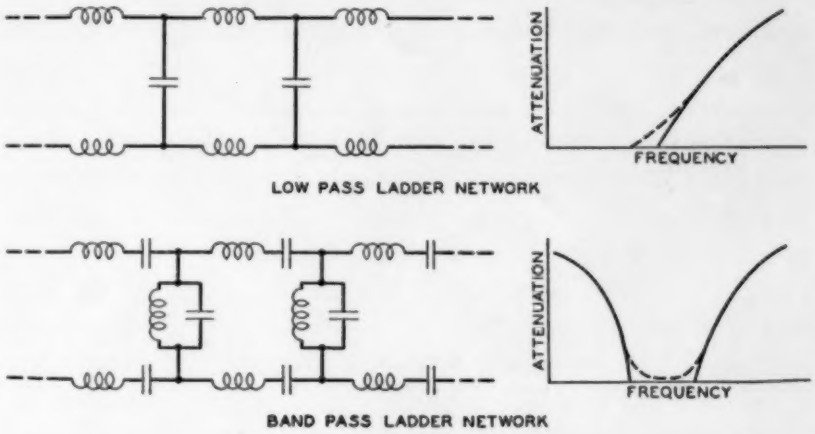


FIG. 3. SCHEMATIC OF LADDER TYPE LOW-PASS FILTER, ABOVE, AND OF A BAND-PASS FILTER, BELOW. THE RESPECTIVE ATTENUATION CHARACTERISTICS ARE SHOWN AT THE RIGHT.

its predecessor of the ladder type. Sharper cut-offs at the edges of the band are obtained with it, and a greater range of characteristics becomes possible in practical filter design. One might expect that further complication of the network would lead to still further possibilities in these directions, but Campbell proved that the lattice structure was as effective as any symmetrical structure that could be derived from combinations of simple inductance and capacitance, thus greatly simplifying the task of later students.

It is unfortunate that it does not seem possible to explain

the action of a filter simply in mechanical terms. A tuned circuit of inductance and capacitance is accurately analogous to a weight supported by a spring. One can devise a mechanical filter likewise from weights and springs in place of inductances and capacitances. One can even observe that it acts as a wave filter; but the explanation of its action is far too complicated to treat other than with mathematical equations, which we need not go into here.

When Campbell's wave filter was first developed, no extensive practical need was apparent for it, but it was nevertheless quickly recognized as a tool of great potential value, and

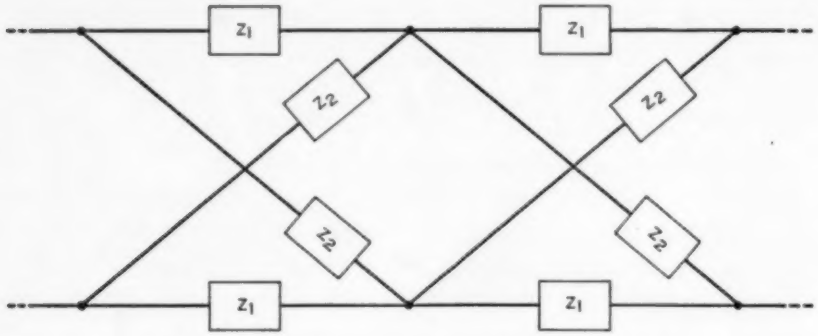


FIG. 4. SCHEMATIC OF GENERALIZED LATTICE NETWORK.

the need for it was not long in coming. The earliest commercial use of a wave filter in a telephone transmission system was made in the first transcontinental line in 1915 to prevent singing in telephone repeaters at frequencies above the voice range. A more extensive demand was created with the introduction of carrier telephone systems in 1916. From these beginnings the use of filters has expanded with great rapidity. Today we find the study of filters and related networks among the most important and productive activities of the Laboratories. Some twenty or more mathematically trained men now devote their entire time to network design, and a staff of five mathematicians is continuously engaged in research in this field.

Some indication of the importance of filters and related networks could be given by mentioning the large amount of money invested in them, but in another sense their actual value far exceeds any estimate in dollars and cents, for without filters many of the savings made in recent developments of long-distance telephony could not have been realized and advances now impending would have been quite impossible. Indeed, the invention of the electric wave filter should be ranked as one of the most important in the history of telephony.

Until quite recently, nearly all of the filters developed for telephone transmission systems have been made from combinations of simple inductances and capacitances in ladder or lattice circuit structures, or in arrangements derived from those simple types. With all such filters, the sharpness of cut-off at the edges of the pass band is dependent on the resistance associated with the filter elements. Condensers can readily be built with low resistance, but practical inductances invariably embody at least the resistance of the the copper wire of which they are wound, and if they employ magnetic cores, resistance is also contributed by hysteresis and eddy currents. It is true that the resistance could be made small by making the coils large, but this quickly runs into practical difficulties at telephone frequencies.

A possible escape from this limitation is to use in place of an inductance coil a mechanical element coupled to the electric circuit in such a way that its mass or inertia appears in the electrical circuit as inductance. Mechanical vibrating systems may be made with extremely small damping so that little mechanical resistance need accompany the inductance so secured. The stiffness of the spring supporting the mechanical mass will, of course, appear as capacity in the electrical circuit, and this must be taken into account.

The quartz crystal filter might be called a semi-mechanical filter. It is an electrical filter, but it uses mechanical mass to provide some of its inductance elements. The mass in this

case is that of the crystal itself. This mass is transformed into inductance, and the stiffness of the crystal is transformed into capacitance, through the "piezo-electric" effect. Quartz is a crystal which generates an electromotive force when subjected to a mechanical stress; conversely, it changes shape when subject to electrical stress. Quartz has another property which is very important. It is a very stable material and can be obtained in large crystals of a high degree of purity. Indeed, we find by X-ray examination that the orderliness of the arrangement of its atoms is extreme.

Let us review some of the steps which led to the introduction of quartz into the filter circuit. The piezo-electric effect has been known since 1880, when it was discovered by the Brothers Curie, but it was not until about 1917 that the effect began to receive serious consideration for practical uses. Indeed, there was no possibility of making much practical use of the effect until the vacuum tube amplifier became available. During the period of the World War, A. M. Nicholson, of the Bell Laboratories, made numerous experiments on devices employing rochelle-salt crystals, which display remarkably high piezo activity. With them he made microphones and loud speakers, and demonstrated a great variety of possible practical applications. About the same time Professor Langevin of France was making practical trials of quartz crystal oscillators driven by vacuum tubes to generate high-frequency sound under water for use in the detection of submarines. Langevin's use of the crystal in this manner inspired others to experiment with it. Professor Cady in this country recognized the value of the quartz crystal vacuum tube oscillator as a source of radio frequencies of high precision. Following Cady's lead, experimenters in the Bell Laboratories developed crystals accurately compensated for temperature changes, and in this way produced frequency controls of very great precision. Today we find nearly all radio broadcasting stations equipped with quartz

crystal controls, and we also find them in small radio transmitters such as those used in airplanes or in police patrol cars.

In its use as an oscillator, the quartz crystal with its attached electrodes behaves much as a simple electric circuit comprising an inductance and two capacitances connected as in Figure 5. However, it is not possible practically to duplicate the performance of the crystal with actual coils and condensers. To build the equivalent circuit would demand coils having less than a hundredth of the resistance-to-reactance ratio of those which are available.

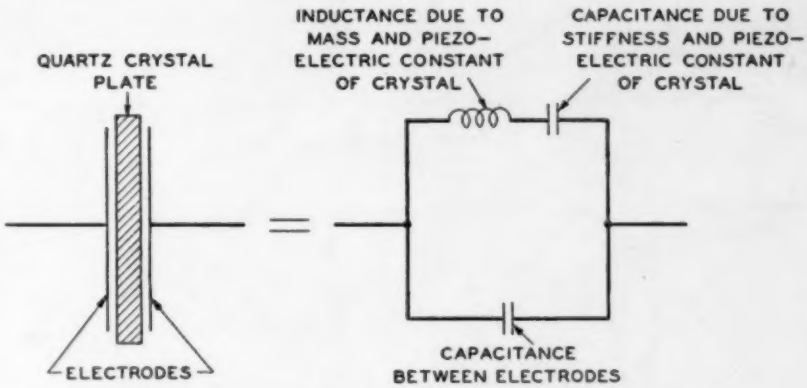

QUARTZ CRYSTAL PLATE
INDUCTANCE DUE TO MASS AND PIEZO-ELECTRIC CONSTANT OF CRYSTAL
CAPACITANCE DUE TO STIFFNESS AND PIEZO-ELECTRIC CONSTANT OF CRYSTAL
ELECTRODES
CAPACITANCE BETWEEN ELECTRODES

FIG. 5. EQUIVALENT CIRCUIT OF A QUARTZ-CRYSTAL OSCILLATOR.

L. Espenschied, at that time of the American Telephone and Telegraph Company, first suggested that a ladder-type filter of sharp cut-off could be made by employing piezo crystals to supply equivalent inductance without the added resistance that is unavoidable when inductance is obtained by the use of coils. The band width that could be obtained with crystals in the ladder network, however, was too narrow to give it a very wide field of application. With this type of filter employing quartz crystals, the ratio of the upper to lower cut-off frequencies had to be less than 1.008, which means that for a 60-kc. carrier the pass band could be only about 480 cycles.

W. P. Mason, of the Bell Laboratories, studied the application of crystals to Campbell's lattice-type network in 1929, and found that by adding an inductance in series with each crystal element in the lattice, the ratio of the upper to lower cut-off frequencies could be increased to 1.135.[1] This made the crystal filter a practical device meeting the requirements of a band-pass filter for broad band carrier telephony. Crystal

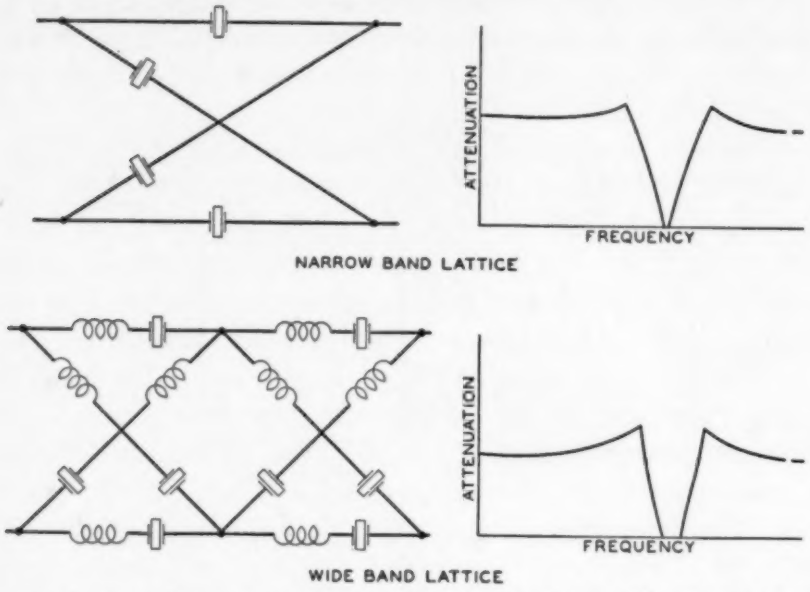


FIG. 6. USING CRYSTALS ALONE, ABOVE, ONLY A VERY NARROW PASS BAND CAN BE OBTAINED, BUT THE ADDITION OF INDUCTANCE, IN SERIES WITH THE CRYSTAL, MAKES IT POSSIBLE TO WIDEN OUT THE BAND OVER FIFTEEN FOLD.

filters with and without the added inductances are shown with their characteristics in Figure 6.

Further studies by Mason indicated that the inductances in the side and lattice arms could be wound on the same core and placed in the side arms as indicated in Figure 7, which is a schematic of the actual filter used in the coaxial cable system.

[1] Space does not permit a full explanation of this and other steps in the design of the network. The reader is referred to Mason's original paper in the *Bell System Technical Journal*, July, 1934.

A bridging resistance was also inserted between the sections to help in sharpening the cut-off. In addition to these modifications, the circuit finally evolved contains added capacitances in multiple with the crystal. These capacitances serve to con-

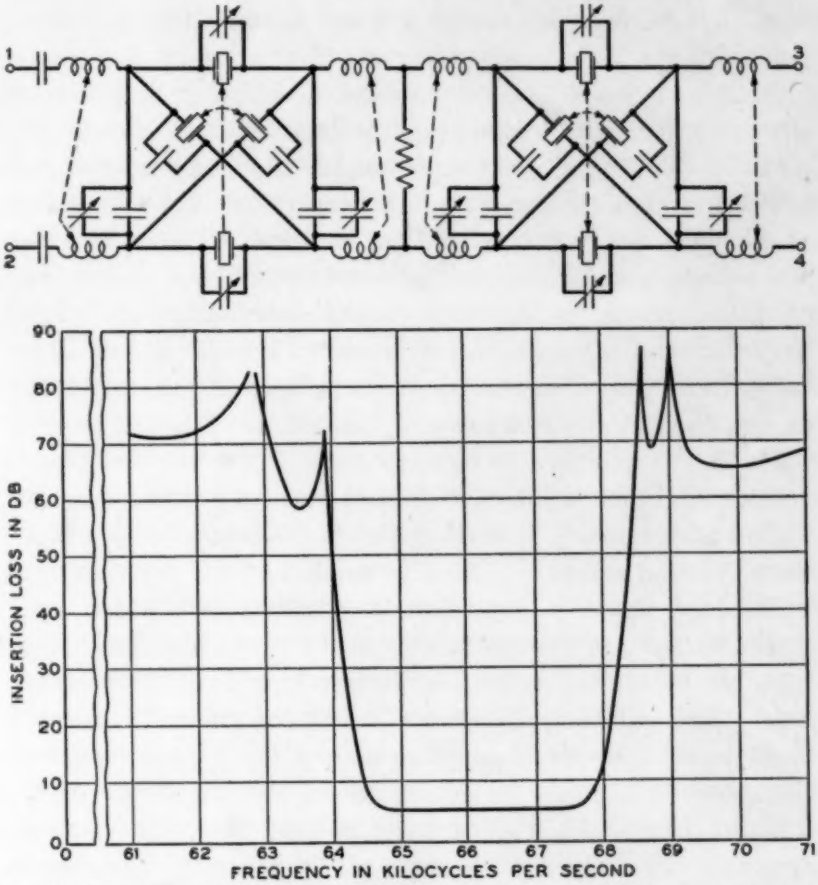


FIG. 7. SCHEMATIC DIAGRAM OF A QUARTZ-CRYSTAL BAND-PASS FILTER, ABOVE, AND THE FILTER CHARACTERISTICS, BELOW.

trol the width of the pass band and to permit fine adjustment.

In the lattice-type network as developed by Mason and embodied in the filter under discussion, the quartz crystals are cut in the shape of thin rectangles from 2.4 to 4.2 cm. long, and with

a width of about 50 per cent, and a thickness of 2 or 3 per cent, of the length. The two broad surfaces of the plate are coated with aluminum deposited from the vapor in a vacuum chamber. This process, now quite familiar to physicists, is the same as that employed in making astronomical mirrors. Electrical contact is made to the metal surfaces through the supporting points.

Such a crystal has several modes in which it may vibrate when excited with alternating voltage of appropriate frequency. There are five simple modes of vibration: two parallel to the edges of the plate, one perpendicular to the surface of the plate, one in flexure, and one in shear. The crystal may also vibrate in combinations and overtones of these modes, any of which may be excited with proper combination of exciting frequency and size and form of crystal. For this filter "longitudinal vibrations" are used, the length of the crystal determining the natural frequency of vibration. Crystals of four different frequencies are used for each filter, but the twelve different designs of filters employed for the groups of twelve 4,000-cycle channels in each of the 48,000-cycle bands are almost identical except for the dimensions of their crystals.

Although it is the length of the crystal plate which principally determines the natural frequency for longitudinal vibrations, the other dimensions are not merely a matter of convenience. Both width and thickness affect the natural frequency through internal elastic coupling among the several modes of vibration. They also, of course, affect the impedance of the crystal. Further, it is not enough to have a crystal which vibrates at the desired frequency. It is necessary too that it should not vibrate at unwanted frequencies. For if there should be a mode of vibration in the attenuating range near the cut-off frequency of the filter, the filter would pass frequencies which it is desired to exclude.

The first filters of this type were made with crystals cut with their thickness parallel to the X or electric axis of the crystal, their width being along the Z or optic axis, and the length

along the Y or mechanical axis. It was found that crystals cut in this manner had a strong coupling to a shear mode of vibration, which would introduce an additional resonance at a frequency 40 per cent higher than the desired frequency. This had the effect of introducing an added pass band at this point, which was undesirable. By studying the elastic constants and modes of vibration of quartz, Mason proved that by cutting the crystal so that its major axis made a small angle (about 18.5°) with the mechanical axis, as shown in Figure 8, there would be no coupling between the longitudinal and shear modes of vibration, and accordingly the crystals for the filter were cut in this manner.

In the circuit diagram of the filter, shown in Figure 7, there are eight crystal elements, whereas in the actual physical structure there are only four. This has been made possible by making one crystal serve for two. The aluminum plating is applied in two parts with a narrow unplated strip separating them. Electrically, therefore, there are two crystals, but mechanically there is only one.

The coils in this filter are also of special interest as a product of research. Their function is to provide inductance where more is required in the filter network than is provided by the equivalent inductance of the crystal itself. Since the filter is to be used at high frequencies, in this case up to 108,000 cycles, the coils must have very low alternating-current losses. Air-core coils can be made which will meet the electrical requirements, but the space occupied, as well as the large magnetic fields, is objectionable, and so cores of magnetic material are employed, but it must be a material with extremely low hysteresis and eddy current loss. The requirement is met by a core of compressed powder of molybdenum permalloy. This material is itself one of remarkably high intrinsic permeability and low hysteresis, and by insulating the separate grains of the powder from which the core is pressed, eddy currents are kept very small.

These coils have another property which is quite important

in this application. They maintain the same inductance over a very wide range of temperatures. This is unusual in coils with ferromagnetic cores, since permeability in general increases rather rapidly with rise of temperature. Molybdenum-permalloy is no exception in this regard, but its increase of permeability with temperature has in this case been compensated by incorporating with it a small proportion of an alloy whose permeability decreases rapidly with temperature. The

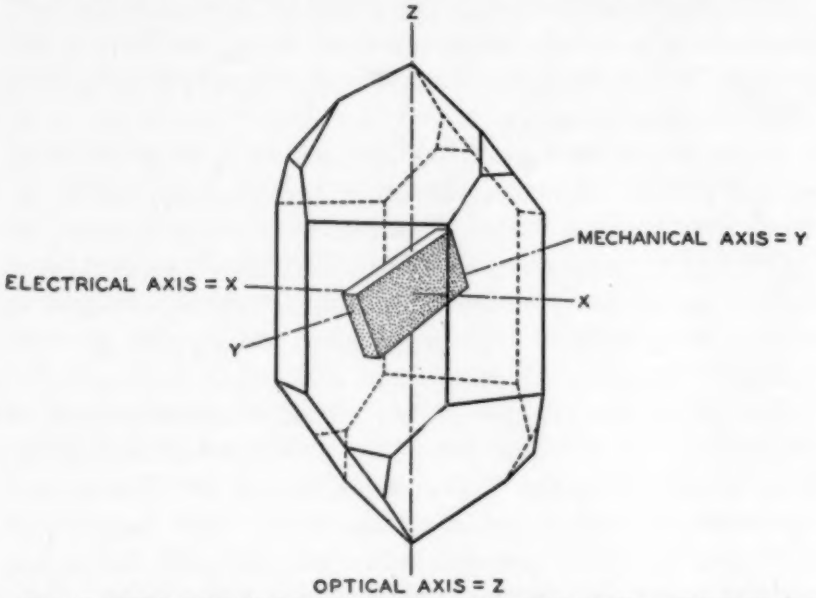


FIG. 8. THE QUARTZ PLATES ARE CUT WITH THEIR FACE PERPENDICULAR TO THE ELECTRICAL AXIS OF THE CRYSTAL, AND WITH ENDS AND SIDES MAKING A SMALL ANGLE WITH THE MECHANICAL AND OPTICAL AXES.

resulting combination displays negligible change of permeability over the range of temperatures to which it is subjected in use.

The evolution of this core presents still another interesting illustration of physical research extending over a long period of time. In this case we must go back thirty years to the first application of inductive loading to telephone lines. The problem then, as now, was to obtain inductance with as little added

resistance as possible. The best that could be done in the first loading coils was to use fine iron wire for the core. This wire had to be drawn to .004-inch diameter to hold the eddy-current loss to the required low value, and this feature made the coils very expensive.

The iron-wire core was soon succeeded by a core of compressed powdered electrolytic iron, the separate grains of which were insulated by a thin coating of shellac. This iron-powder core was used in loading coils from 1916 to 1927, when it was succeeded by the smaller permalloy-powder core, which in turn is now being succeeded by the still smaller and cheaper molybdenum-permalloy-powder core.

Permalloy is a nickel-iron alloy of very high permeability and low hysteresis, which was first developed for loading submarine telegraph cables. It is a tough, malleable metal, and considerable development work was required to produce a satisfactory method of reducing it to powdered form. After the molybdenum permalloy has been powdered, the individual particles must be insulated. The insulation must be thin, so as not to introduce too large a magnetic gap between adjacent grains; it must withstand the effect of compressing the grains into a solid mass of nearly the density of solid permalloy; it must be refractory, so as not to be broken down in subsequent heat treatment; and it must retain its insulating quality through compression and heat treatment.

With the crystal wave filter, as with all other products of research, the task of producing the practical apparatus in form for manufacture and use was not completed with the solution of the problems to which I have referred. No less important are the many steps of engineering development that had to be taken to insure that the apparatus could be made economically and would always work. Among such steps were the development of methods of cutting and plating crystals, the development of a successful mounting for the crystal, provision for precise adjustment, shielding from electrical interference, and

protection from moisture. In these features of the development we would find similar evidence of evolution.

Although it is impossible in a few pages to bring out the effort that has been expended in the past thirty years in developing this unimposing but important exhibit, enough has been given, I trust, to explain what was meant by the statement that industrial research is an evolutionary process. A consequential feature of industrial research is that it is a long time in the doing and calls for patience not only from the investigator but from his financial supporters.

Another striking feature which is characteristic of nearly all research is that applications are found in quite unexpected fields. In this case, researches on the loaded telephone line, the transatlantic cable, the use of crystal to detect submarine, the study of the diffusion of impurities through metals, the plating of metals by evaporation, all found application in a way which could not possibly have been anticipated while the fundamental work was being done.

But the most important feature of all is one which the preceding discussion has done little to bring out. It has to do with the character of the men who brought this filter into being, and the spirit of investigation which guided them. Men of many types, working in different fields of research, have contributed their bit to this development, but these men all have certain characteristics in common: good minds as a foundation, many years of learning in the fundamentals of their science and the methods of research, and a coöperative attitude; for without coöperation of individuals these synthetic products of research could never be produced. Above all else, however, they had "the spirit to adventure, the wit to question, and the wisdom to accept and use"[2] which seems to me the best summary of the requirements for a research worker.

OLIVER E. BUCKLEY

[2] H. D. Arnold, in the BELL TELEPHONE QUARTERLY, April, 1932, page 96.

Making Neighbors of Nations

An Anniversary

MAN against the Atlantic—what high adventure that struggle has brought since the venturesome voyage by the Santa Maria and its determined commander! Nearly 350 years after Columbus another significant transatlantic crossing was made by the "Great Western," which was the first of the transatlantic liners. Its trip from Bristol, England, to New York took only two weeks. A few years later, in 1858, the first transatlantic cable was laid, and communication across the Atlantic was no longer dependent on water transport.

In the years prior to the turn of the century, men of science were learning things about electric impulses, which showed a surprising readiness to jump off metal conductors and travel through the air; and in 1901, one of the young men investigating these phenomena, Guglielmo Marconi, startled the world by flashing "International S" through the air across the broad Atlantic. During the next quarter of a century research and development brought about still further advances in transportation and in communications. A striking parallel occurred in that, during this period, science turned to the air as a new medium for operations in the fields of both communication and transportation.

While the airplane was becoming a scientific and commercial achievement, telephone engineers were working zealously at turning wireless impulses into speech—teaching them to carry syllables, just as Alexander Graham Bell had taught the impulses from a wet cell battery to carry syllables along a wire. In 1927, there occurred two other significant victories over the Atlantic—one by transportation, when Lindbergh, in May,

flew a single-engined airplane non-stop from New York to Paris; and the other by communications when on January 7, 1927, just ten years ago this month, the work of the scientists and engineers in the field of radiotelephony culminated in the inauguration of telephone service across the Atlantic between New York and London. Now, on this tenth anniversary of the bridging of the Atlantic by telephone, it may be of interest to glance backward over the record.

Much has been written upon the fundamentals and technique of radiotelephony as demonstrated and applied in overseas service. The advances in the science are indeed remarkable. They are part, however, of the story of engineering achievement which it is not the intention to tell here. This article is merely intended as a brief history and outline of the scope of Bell System overseas telephone service and the steps by which the infant service of ten years ago is attaining full stature.

As far back as 1914, Bell System engineers were looking forward to the possibility of projecting the human voice across oceans. The high vacuum tube had been developed sufficiently to offer the key to the attainment of radiotelephony. The famous Arlington tests with Paris, Panama, and Hawaii were made in 1915. Despite interruption by the war, prospects of actually applying radiotelephony for service across the Atlantic began to take form by 1923. To put to practical use this new science meant pioneering in an untried field and risking a considerable expenditure in apparatus on both sides of the ocean.

The first efforts were concentrated on spanning the Atlantic between the nearest practicable points. Along the Great Circle route the closest land was the British Isles, although in those days there was considerable doubt that a radiotelephone circuit would work successfully over such a distance. The British General Post Office had available a toll wire network extending from London throughout Great Britain and also, in coöperation with other European telephone administrations, had developed

an extensive toll layout to many European countries. The favorable distance factor and the existence of the wire networks at both ends, coupled with the further advantages of a common language and the potential traffic volume to be expected between the two great financial centers of New York and London, led to the establishment of the first link (a long wave channel) across the Atlantic as a New York-London circuit.

Early Extensions of Transatlantic Service

Shortly following the opening of this circuit, the service was extended beyond the terminals of the radio circuit by means of the wire toll lines at each end, so that by the end of 1927 all of the United States and Cuba, together with a part of Canada, was interconnected with Great Britain.

How best to extend service to the countries on the European continent was the next problem. It appeared that, at least during the early development years of the radiotelephone service, the best and most reliable way to serve such countries was by utilizing the extensive wire telephone network radiating from London to the principal European countries, in combination with the radio link which had been established.

By this means service was extended in 1928 to many of the countries in western Europe, such as Belgium, the Netherlands, Germany, Sweden, France, Denmark, Norway, Switzerland, Spain, Austria, Hungary, and Czechoslovakia. Although for some years to come the volume of traffic to the continent appeared likely to be small, it seemed that direct circuits to the larger countries in Europe eventually would be required. The tentative plans for the future, as then formulated, took this probability into account.

A second important step in the overseas plan was to strengthen the initial radio link to provide a more reliable pathway across the Atlantic. Bell System engineers had been studying and testing short waves. The results indicated that

with highly directional antennas a satisfactory overseas circuit could be obtained with much less power than was required for the long wave circuit. Furthermore, the short wave characteristics would conveniently supplement the long wave characteristics, since the two types of circuit were found to be affected differently by varying radio transmission conditions.

In order to insure reliable telephone service for any considerable volume of transatlantic traffic, it was deemed desirable to build up the New York-London route as the "backbone" route. Therefore, three short wave channels were designed to supplement the long wave circuit, the first short wave channel being placed in service in June, 1928. With the later installation of the remaining two short wave channels in 1929, there was available a four circuit group, diversified as to type of radio channel and with sufficient capacity and a fair degree of reliability to care for the future transatlantic demand as it arose.

Toward the end of 1929, most of North America, including part of Mexico, was connected for service with Europe. Several additional European countries, such as Italy, had also been added to the transatlantic telephone network.

Overseas Fundamental Plan

In July of 1929, applying the experience gained with the early transatlantic radio circuits to Europe, a fundamental plan for overseas service was formulated, with the aim of placing the United States in communication with the rest of the world as rapidly as technical developments and the prospects for traffic warranted. The fulfillment of this plan for a world telephone network radiating from the United States westward and southward as well as eastward was the next important step in the pioneering stage of overseas service.

It may be of interest at this point to note that of the thirty countries outside of Europe considered at that time for the

extension of service, twenty-three are now served and two more will soon be added.

Heading South

The first move toward the world plan was soon made. Looking southward, arrangements were completed with the Compania Internacional de Radio, a subsidiary of the International Telephone and Telegraph Corporation, located in Argentina, to establish a short wave radiotelephone circuit between New York and Buenos Aires. This circuit was opened in April, 1930, and provided service between North America and Argentina, Chile and Uruguay—the latter two countries being reached by wire lines from Buenos Aires.

In 1931, a direct connection was also established with Rio de Janeiro, Brazil, utilizing the same stations at this end as were used for Buenos Aires, the new connection providing service to the telephone network of Brazil.

Later, in 1932, Lima, Peru was added as a direct connection, and by 1935 Paraguay was also connected, being reached by wire lines from Buenos Aires.

Transpacific and the Far East

Meanwhile, the radiotelephone continued its steady march across the world in other directions. Having bridged the Atlantic and connected North and South America, the telephone dared to challenge the mighty Pacific. The fundamental plan pointed the way for a transpacific station and so, in December, 1931, from radiotelephone centers established near San Francisco, a short wave channel was provided between that city and Honolulu, Hawaiian Islands. This circuit, used in combination with the wire lines and the inter-island short wave radiotelephone system of the Mutual Telephone Company of Hawaii, binds closer to the mainland that distant bit of American territory.

The transpacific station was utilized in March, 1933, for a further jump west. A direct connection was established between San Francisco and Manila, through arrangements with the Philippine Long Distance Telephone Company, providing service to that easternmost outpost, the Philippine Islands.

Some years back, in 1931, Java and Sumatra in the Netherlands Indies, those famed islands of travel and adventure, had been added for service by a combination of facilities reaching half way round the world *eastward* from the United States. The makeup of the route was unusual: transatlantic radio channel New York to London; wire lines London to Amsterdam; and radio again between Amsterdam and Bandoeng, on the island of Java. Bandoeng had short wave connections with Sumatra to complete the last link in the chain. This was a long route with several switches and types of facilities, so, in order to shorten and simplify the route, in 1934 direct connection was established with Bandoeng from San Francisco *westward*.

Late in 1934, direct connection was made between San Francisco and Tokyo, thus providing service to Japan, some five thousand miles distant and nearly a day earlier in time. Incidentally, the wide time difference on the transpacific channel causes many special problems of operation and scheduling and, of course, is somewhat of a handicap as regards the short period during which the business days on the two sides of the Pacific overlap. Nevertheless, it is surprising how easily both the user and the operating force adapt themselves to the jumping calendar.

Finally, to nearly complete the roster of far eastern countries, it should be mentioned that tests are under way, looking toward service with China.

Around the World by Telephone

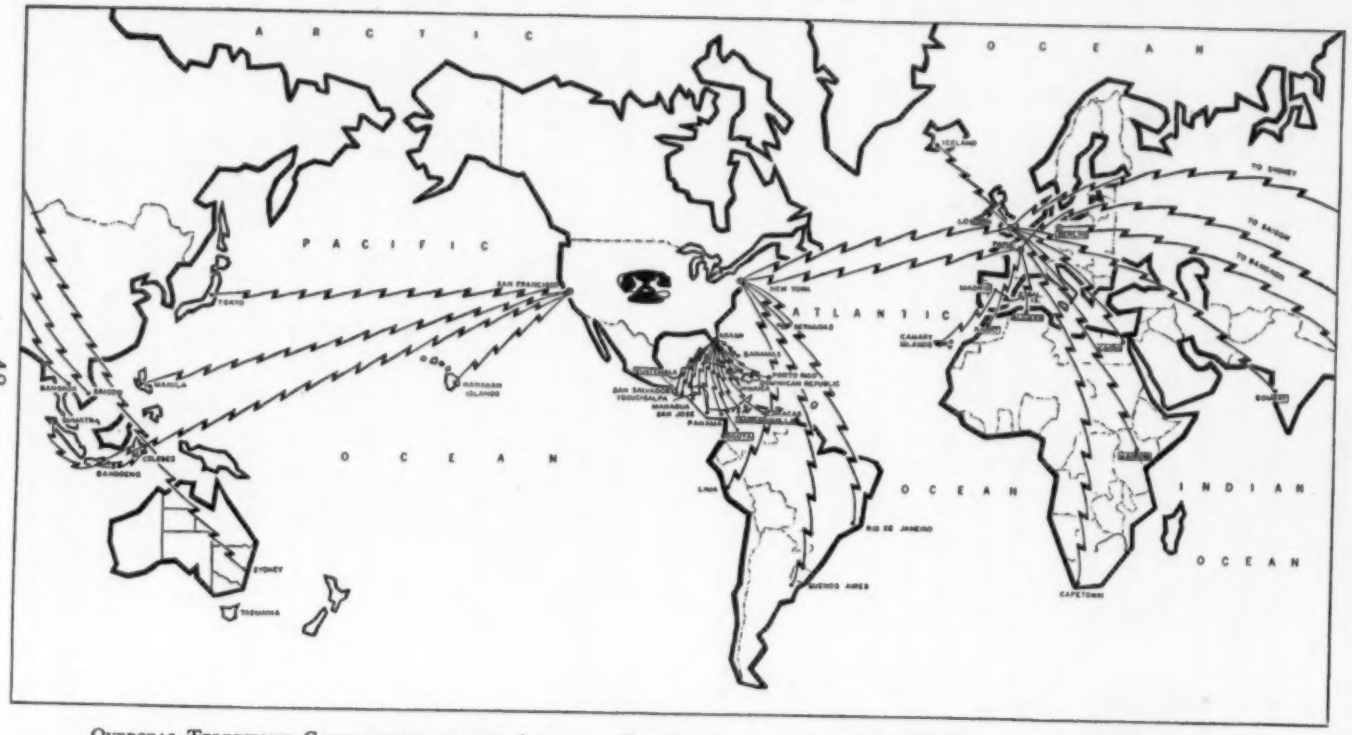
It may be well to digress a moment to tell of a rather significant event arising out of the change from *eastward* to *west-*

ward in the route to Java. When this change in route was an accomplished fact, the overseas telephone network had spanned the world. To mark this achievement an "Around the World" circuit was set up on April 25, 1935, with the cooperation of the Netherlands Indies Telephone Administration, the British Post Office, and others. Starting and terminating at New York, this circuit was composed of a New York-London radiotelephone channel, wire lines between London and Amsterdam, a radio link again between Amsterdam and Bandoeng, another radio channel from Bandoeng to San Francisco, and, finally, wire lines from San Francisco to New York. Sitting in one room at 32 Sixth Avenue, the Long Lines building in New York, Walter S. Gifford, President of the American Telephone and Telegraph Company, conversed around the world with T. G. Miller, Vice-President in charge of the Long Lines Department, who was seated in the next room.

Caribbean and Atlantic Coast

While the march westward was on, still further expansion was taking place along the Atlantic coast.

Late in 1932 a new radiotelephone center to serve Central America and the Caribbean area was established near Miami, Florida. A short wave channel was provided which was first used for connection to Nassau, in the Bahama Islands. This Caribbean circuit, operated on a "party line" basis, was designed so as to serve a number of countries direct. Venezuela and Colombia were also connected for service shortly thereafter, by arrangements with telephone companies which operate in these territories and which are allied with the Associated Telephone and Telegraph Company. In collaboration with the Tropical Radio Telegraph Company, operating in Central America, the countries of Panama (including the Canal Zone), Costa Rica, Guatemala, and Nicaragua were added for service in 1933 and Honduras in 1935. The Dominican Republic was also connected for service with the Miami station in 1935.



OVERSEAS TELEPHONE CONNECTIONS OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY AND ASSOCIATED COMPANIES.

Puerto Rico, Jamaica, and Salvador followed in 1936. Thus, service to most of the countries and islands of the Caribbean area is well established.

Farther north on the Atlantic coast, in 1931, a short wave channel was established between New York and Hamilton, Bermuda, linking this well-known island into the overseas telephone network.

Now, turning back to the first overseas route, the transatlantic, a few of the more unusual extensions of the scope of service along that route are worthy of attention.

Later Extensions on the Transatlantic Route

Service to Australia was opened in 1930, using the New York-London and the London-Sidney channels, the first case of two radio links in tandem. South Africa, Egypt, and Siam were added, using similar tandem radio channels, in 1932, and also India in 1933. Palestine was reached through Egypt in 1933 and Syria in 1934 by means of wire lines beyond the radio terminal at Cairo. Algeria, French Morocco, Tunisia, and French Indo-China were added for service in 1934, all being reached through England and France, which latter country has radio circuits to these distant territories. Iceland was reached in 1935 by means of tandem radio links via London, and Kenya in Africa was added, by the same means, in 1936.

On December 1, 1936, a direct short wave radiotelephone channel was established between Paris and New York to carry the traffic between France and the United States. This single direct circuit is supplemented by the use of the New York-London "backbone" circuit group for periods when the direct New York-Paris circuit is not in service. As conditions warrant, it is planned that other countries in continental Europe will be reached by direct connections from the United States.

Today there is available, to the public of the United States, telephone service to nearly seventy countries and territories

scattered throughout the globe, and to the neighboring nations of Canada, Cuba, and Mexico. To the latter territories, of course, service has been available for many years by wire lines.

At this point a glance at the route layout may be of interest. Of the nearly seventy countries and territories reached, there are now twenty-two with which the United States has direct connections. The other forty-odd territories are reached via the countries with which the direct connections are made. The circuits radiating from the United States are centered at three focal points:—New York, which is the terminal point for the transatlantic and the most distant southern routes, has direct connections with England, France, Argentina, Brazil, Peru, and with Bermuda; Miami, which is the terminal for the Caribbean area, has connections with the Bahamas, Dominican Republic, Jamaica, Puerto Rico, various points in Central America, Colombia, and Venezuela; San Francisco, which is the terminal for the transpacific area, has connections with Hawaii, Japan, Java, the Philippines, and will connect soon with China. It should be noted that much of the service at present is on a party-line basis, that is, several countries are served by a single transmitting channel from this end which is switched between the distant terminals as traffic requires. Undoubtedly, as traffic develops, individual circuits or circuit groups will be required for the larger countries. Although there are, naturally, some departures, it is surprising how closely the present network follows the fundamental plans outlined early in the development of overseas service.

Service Arrangements and Rates

Overseas service is closely akin to the telephone service given within the Bell System, but as it is rendered jointly with foreign administrations or companies outside the Bell System and is provided by radio rather than by wire, there are some essential differences in the type of services offered and in the

arrangements under which it is given. In many instances the service is rendered under circumstances where both the time of day and the language are different at each end of the route. Further, there is the necessity of developing methods which will appeal to the public of various countries which may have telephone service, habits and methods differing widely from those in the Bell System. In this connection it may be well to point out that the Bell System does not own nor have any financial interest in any of the distant ends of the overseas radiotelephone services.

The arrangements for overseas service with the various companies and administrations in the overseas territories may be of interest. For each territory with which there is a direct connection there is executed a so-called "service agreement" which, in general, is not unlike a Bell System "connecting company agreement." These agreements, in brief:—provide that each company or administration shall establish and maintain the requisite facilities for the service at its end; cover the basis for the rates and the exchange of currencies; and specify methods for the collection and division of revenues. Also contained therein are commitments as to the use of standardized practices and uniformity of accounts. The arrangements with the twenty-two overseas administrations directly connecting with the Bell System by radiotelephone are practically the same, except for some minor differences. The service between the United States and each territory with direct connections is operated jointly by the Bell System on one side and the company or administration on the distant side, and the division of the revenue from the radiotelephone haul is divided equally between the two sides, each side bearing its own expenses. In fact, except for ship-shore service, where the revenue is divided one-third to the ship station and two-thirds to the shore station (because of the greater power and more extensive operating furnished by the shore station), the overseas services are truly joint partnerships on a "fifty-fifty" basis. Although

these fundamental arrangements, as can be readily seen, are quite simple, the necessary details of handling the service by joint agreement as to the commercial practices, traffic procedures, plant operating methods and engineering standards are, of course, manifold in number and often complex in character.

The following table shows the direct overseas routes from the United States, and the name of the administration which is the contracting party at the other end of the direct connection. It is opportune here to say that the sincere and hearty cooperation of the overseas administrations interchanging traffic with the Bell System has been one of the most important factors in the establishment, extension, and improvement of the overseas telephone service.

Route	*Connecting Administration*
New York—London, England	General Post Office—British Gov't
New York—Paris, France	Dept. of Posts, Telegraphs & Telephones—French Gov't
New York—Buenos Aires, Arg.	Compania Internacional de Radio
New York—Rio de Janeiro, Brazil	Companhia Radio Internacional
New York—Lima, Peru	Compania Peruana de Telefonos
New York—Hamilton, Bermuda	Halifax & Bermudas Cable Co.
San Francisco—Honolulu, Hawaii	Mutual Telephone Company
San Francisco—Manila, Philip. Is.	Philippine Long Distance Tel. Co.
San Francisco—Bandoeng, Netherland Indies	Dept. of Posts, Telegraphs & Telephones—Netherlands Indies Gov't
San Francisco—Tokyo, Japan	Dept. of Telecom.—Japanese Gov't
Miami—Nassau, Bahama Is.	Government of the Bahama Islands
Miami—Bogota, Colombia *	Compania Telefonica Central
Miami—Caracas, Venezuela	Compania Anonima Nacional Telefonos de Venezuela
Miami—San Jose, Costa Rica	Tropical Radio Telegraph Company
Miami—Panama City, Panama	Tropical Radio Telegraph Company
Miami—Guatemala City, Guat.	Tropical Radio Telegraph Company
Miami—Managua, Nicaragua	Tropical Radio Telegraph Company
Miami—Tegucigalpa, Honduras †	Tropical Radio Telegraph Company
Miami—Ciudad Trujillo, Dom.	Compania Dominicana de Telefonos
Miami—San Salvador, El Sal.	Government of El Salvador
Miami—San Juan, Puerto Rico	Porto Rico Telephone Company
Miami—Kingston, Jamaica	Jamaica Telephone Company

* There are two other direct connections with Colombia from Miami, one with Barranquilla and the other with El Centro.

† There is another connection to La Lima, Honduras.

The rates for overseas service on the New York-London route between Great Britain and the east coast of the United States were first established as $75.00 for the initial three minutes and $25.00 for each additional minute. The United States, and later the remainder of North America, were divided into large rate zones and zone charges were added to the base rate mentioned, for calls beyond the first zone. This zone system, modified somewhat as to zones and zone charges, is still in effect for overseas service. On the European side a similar zone plan is in effect for countries reached by wire lines beyond the radio terminal. On other routes to countries in South America and the Far East, rate zones have also been set up in certain of the foreign territories where long wire hauls beyond the radio terminals are involved.

Early in 1928, the transatlantic rates were reduced to $45.00 for the initial period and $15.00 for each additional minute, and again in May, 1930, were further reduced, this time to $30.00 and $10.00. In the meantime, similar rates had been introduced on the new routes which were opening up, ranging in level from $30.00 on routes such as the South American and transpacific to a $12.00 rate for the Miami-Nassau channel, which is one of the shortest radiotelephone links radiating from the United States. Night rates were introduced on the transatlantic route, which is the only route operated at present during the entire twenty-four hours, in June, 1935, at a level 30 per cent lower than the day rate.

Between July and November, 1936, the rates on most of the overseas routes from the United States were reduced from 30 per cent to 50 per cent, while at the same time Sunday rates approximately 30 per cent lower than the weekday rates were introduced on practically all routes. Today the rates on direct routes usually range from $21.00 for weekday service and $15.00 for Sunday service on most of the longer routes down to $7.50 for weekdays and $5.25 on Sundays on the shorter radiotelephone routes.

Passing of Pioneering Stage

The pioneering stage of the overseas development is now passed. The establishment of most of the important fundamental primary routes is well along and service is extended to almost all of the larger countries. In fact, the number of telephones which may be reached from any Bell or Bell connected telephone comprises 93 per cent of the world's telephones.

Strengthening and improving this present radiotelephone network and the service it renders is the next step in the upbuilding of overseas telephone service. In fact, plans are now under way to improve the transatlantic short wave circuits within the next two years and in the near future to provide direct service to additional European countries.

Elsewhere in the world, while the overseas telephone network from the United States has been growing, radiotelephone services have been established radiating from other countries, so that today many of the larger countries have rather extensive systems. Of these larger nations, Great Britain, France, Germany, Italy, Holland, and Spain of the European nations; Japan, in the Far East; and Argentina and Brazil in South America, in particular have actively developed overseas radiotelephone routes, so that along the usually travelled world lanes everywhere one now finds the overseas telephone paralleling the age-old trade routes.

Use of the Service

Since that first year of overseas service, when the traffic averaged only a few messages a day (about 2,000 messages were handled in 1927), the volume has increased from both the addition of new territories and from growth in calls with countries already connected until today, at recent levels, the total overseas traffic on a yearly basis would approximate

50,000 messages. Of these, the transatlantic traffic generally ranges from 60 to 65 per cent.

Although no recent analysis has been made, it is estimated that about half the day-to-day traffic volume is comprised of business calls and the rest is made up of calls relating to social or personal matters. This usage is by all types of business and people. Probably the greatest use of the service is for the transaction of financial matters. World happenings of widespread interest, such as the events at the time of the abdication of King Edward VIII, and the devaluation of the monies of various countries, often bring sudden sharp peaks in the traffic load. But day in and day out the increasing volume consists of calls made, in the main, because there is a work-a-day job to be done in finance, in sales, in engineering, in manufacturing, and because there is the need to keep families or friends in touch with each other. What, a short ten years ago, was a great adventure in crossing the seas by telephone has now become a familiar experience to many in the everyday conduct of their affairs. And yet there remains the thrill which always seems to be associated with ocean voyages by voice or in person, and why wouldn't it be a rather thrilling experience, however often it happened, to hear a "hello mother!" or a real Yankee "Howdy Jim!" from Cape Town or Manila! Yet for all the wonder of it, the service is already in use regularly as one of the modern conveniences of 20th Century life.

In one phase of human life the overseas telephone has filled a need that could have been filled by no other means—except perhaps television. To members of a family separated by thousands of miles there is nothing that quite equals the elation of hearing each other's voices. Especially at holiday time is the need for this contact strong, and so each year has witnessed a tremendous increase in the volume of Christmas and New Year's greetings across the seas by telephone.

In 1935, the transatlantic traffic on Christmas day totalled 246 messages, and on all overseas routes 358 messages. In the holiday season just passed, the overseas traffic on Christmas was 674 messages, an increase of 88 per cent over the year before; and on New Year's Day of this year, 365 overseas messages were handled, over three times as many as on that same day last year. From the results it will be seen that it was a truly Merry Christmas and Happy New Year for the Overseas Telephone Service, coming just at the appropriate time to add to its pride in celebrating its tenth birthday on January 7, 1937.

W. G. THOMPSON

Equipping the Telephone Fleet

IN an article published in the QUARTERLY of January, 1936, under the title "Engineering the Telephone Fleet," body equipment for Bell System motor vehicles was discussed. This large and gradually growing fleet, now numbering some 17,500 vehicles, is constantly changing, due to the replacement of worn out and obsolete cars, trucks, and associated equipment and to the addition of units to care for growth. New vehicles are always supplied with the latest equipment, to provide maximum assistance to the men engaged in the various kinds of work necessary to the construction and maintenance of the Bell System's outside plant. Through this process, the design standards of the motor vehicle equipment are constantly being improved.

Various kinds of equipment which are associated with the vehicles are described in this article in some detail. These include: trailers for carrying materials and tools which cannot be conveniently or economically carried on the trucks; trailers for serving as storehouses for the men when the units do not need to be moved frequently enough to warrant the continual use of a car or truck; devices to improve the economy and utility of the vehicles in telephone work; various types of power operated equipment especially adapted to assist the gangs in the many kinds of work they have to do; and other accessory devices which are hand operated.

Generally speaking, this equipment has been designed or adapted to field requirements by Bell System engineers. It is observed in service, so that improvements can be made, better fitting it to existing requirements; and as new conditions arise, the designs are modified to meet them.

Trailers for Carrying Poles and Other Materials

Transporting new telephone poles from the yards out to the line and hauling old poles away from the locations where they are removed becomes a big operation in the aggregate when it is considered that in the neighborhood of a million poles a year are set by the telephone companies. Generally speaking, the poles are transported on medium or heavy duty two wheel trailers (Figure 1) upon which the load of poles is practically balanced.

These trailers are equipped with an extensible tongue, which is connected to a towing hook built into the rear of the truck when medium length and short poles are carried. For transporting very long poles, the first pole loaded on the trailer bolsters is placed in the middle of the load and permitted to project ahead of the rest of the load, so that when the tongue and poles are properly lashed together this center pole, with a suitable draw bar fastened to its front end, serves as the tongue.

It has been found to be most satisfactory to bind the pole loads with wire rope by means of small hand operated winches especially designed for this purpose. Of course, the removable sliding stanchions, two on each side, also help to hold the load in place.

These trailers in the medium and heavy duty sizes weigh 2,900 and 3,800 pounds respectively, and carry loads of from three to eight tons. In keeping with the somewhat higher road speeds now prevalent with pneumatic tired trucks, these trailers are being built with dual pneumatic tires instead of the solid tires which have been used generally in the past. Also, electric brakes, which are operated by a rheostat in the cab convenient to the truck driver, have been found advantageous. In some instances, vacuum booster operated hydraulic brakes have been used. They, too, are operated from the cab by remote control.

There has been for some time a tendency in telephone work

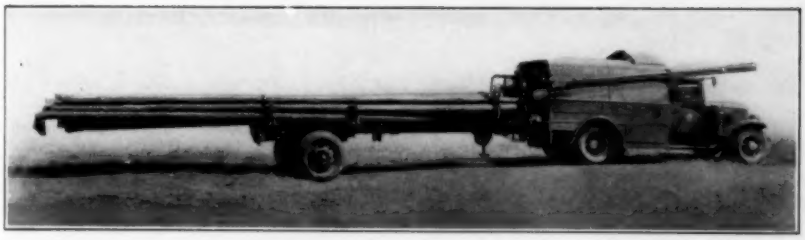


FIG. 1. BALANCED LOAD OF POLES CARRIED ON "HP" OR "MP" TRAILER.

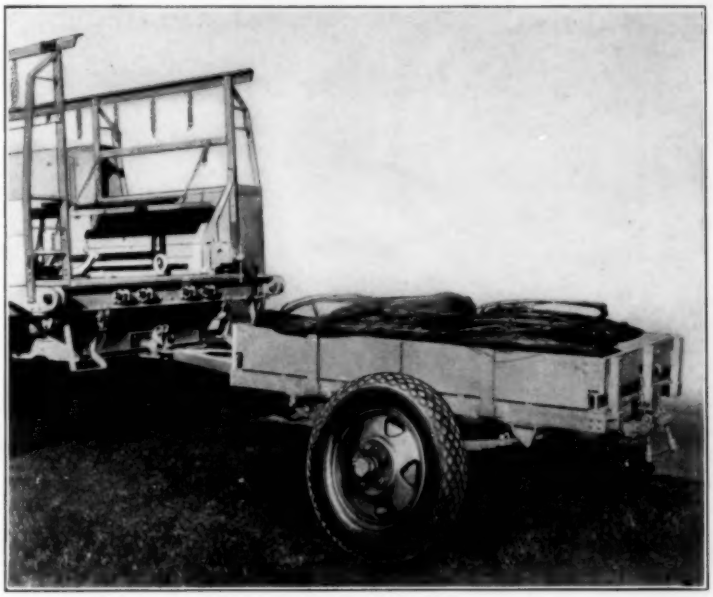
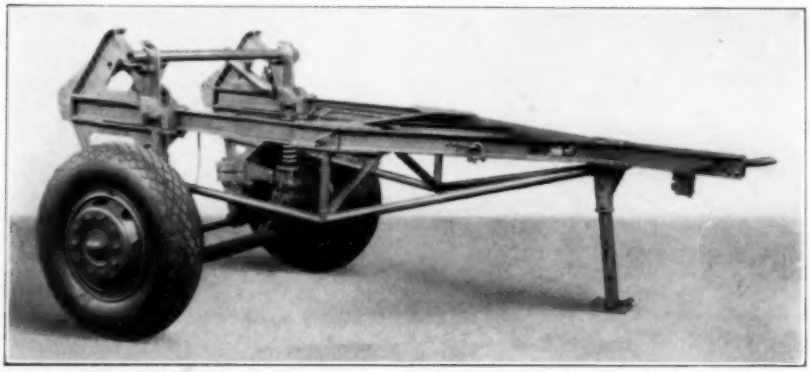


FIG. 2. JUNK ON "SLP" TRAILER.

FIG. 3. LIGHT POLE LOAD ON "SLP" TRAILER.

FIG. 4. SPLICER'S EQUIPMENT IN "S" TRAILER.

FIG. 5 (BELOW). "PCP" TRAILER WITH SADDLES FOR CARRYING REELS OF CABLE.



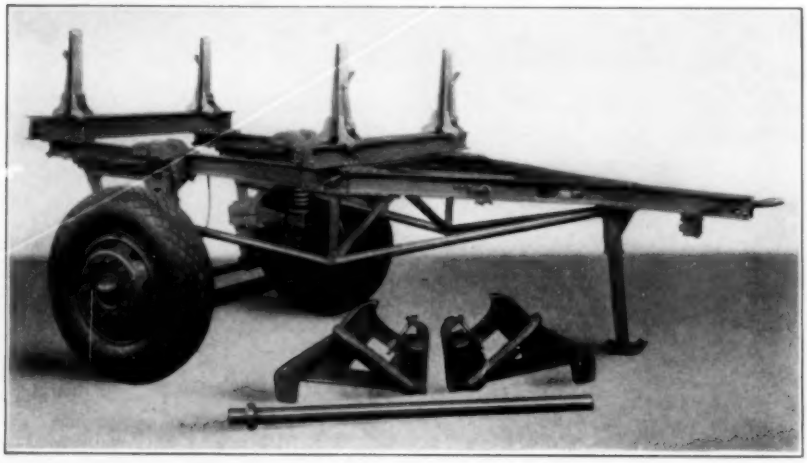


FIG. 6. WITH SADDLES DETACHED, "PCP" TRAILER IS EQUIPPED WITH BOLSTERS FOR POLE HAULING.

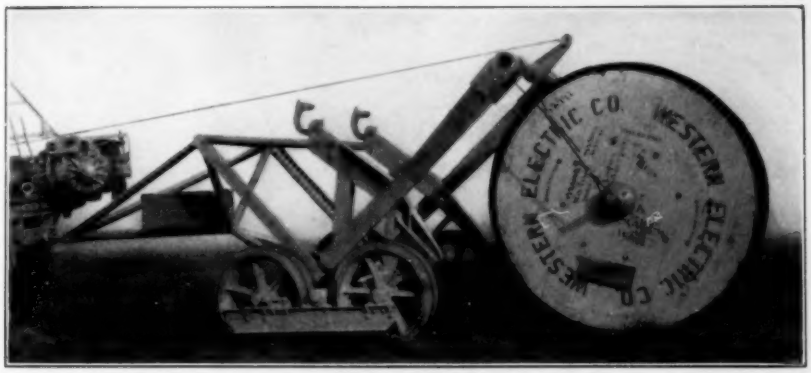


FIG. 7. (ABOVE). WINCH LOADING TRAILER, TYPE "WL," IN POSITION TO START TO LOAD A REEL.

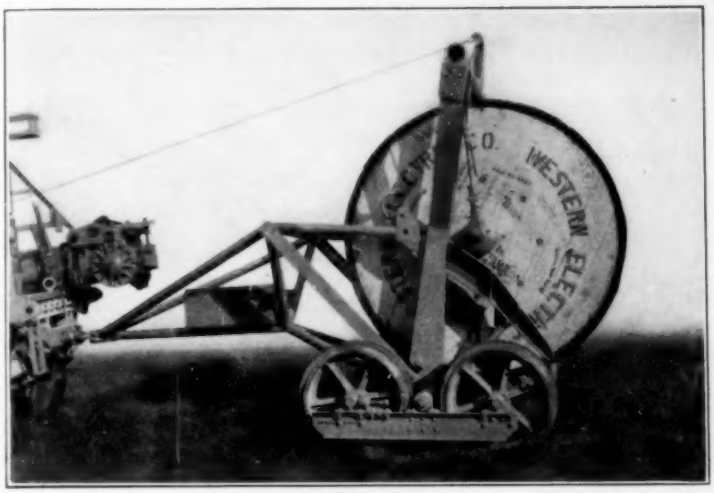


FIG. 8 (LEFT). REEL BEING DRAWN UP ON "WL" TRAILER BY WINCH LINE.

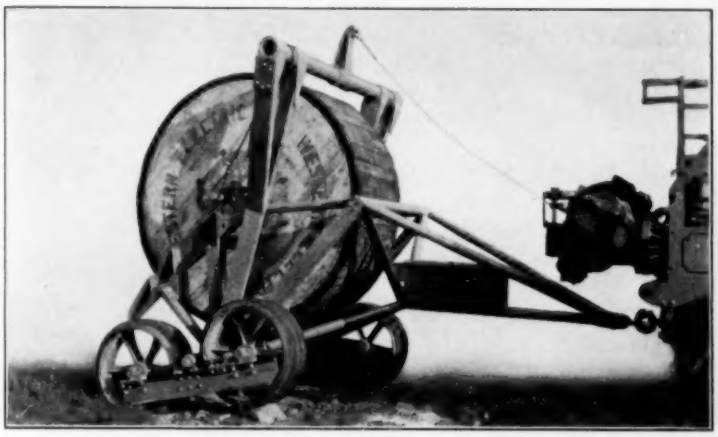
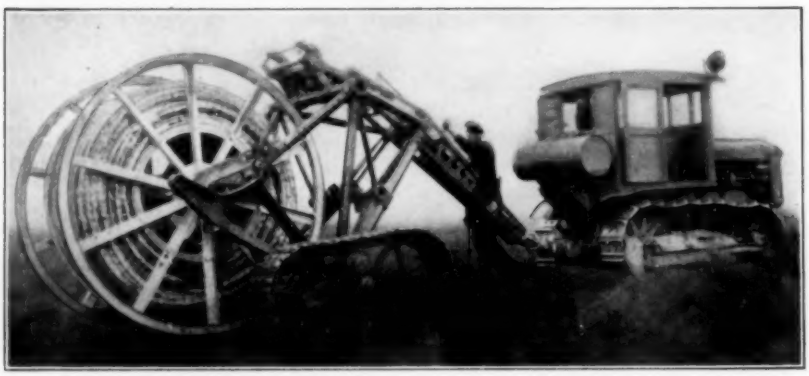
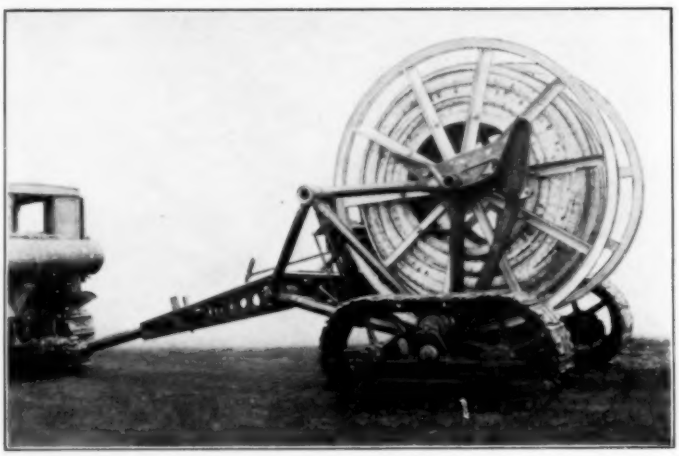


FIG. 9. REEL OF CABLE IN TRAVELING POSITION, "WL" TRAILER.





TRACTION LOADING "TL" TRAILER. FIG. 10 (TOP): JACK-KNIFED READY TO PICK UP REEL. FIG. 11 (CENTER): LIFTING REEL, WITH TRACKS LOCKED. FIG. 12 (BOTTOM): IN TRAVELING POSITION.

toward the use of lighter trucks. The carrying of heavy materials, such as reels of cable or suspension strand, loads of crossarms, etc., by suitable trailers relieves the trucks of these loads. Practically no weight is added to the truck by the balanced trailer loads, as in the case of the poles mentioned above. As an additional advantage, the single axle trailers require a minimum of storage space.

A light type of trailer (Figure 2) is used for carrying coils of wire, crossarms, tree trimmings, etc. This trailer weighs about 850 pounds and has a carrying capacity up to about two tons. It, like other telephone trailers, is of the two wheel type, in order to provide maximum ease in maneuvering, is light in weight in relation to carrying capacity, and is low in first and maintenance costs.

This trailer serves a dual purpose. With the removable sides and ends of the box body taken off (Figure 3), it becomes a light duty pole trailer. The tongue being short and of the fixed type, it is necessary always to use the center pole as a tongue.

Splicers' Trailers

Another type of trailer (Figure 4) is used in a different class of work by telephone gangs. Many cable splicing jobs require a considerable length of time. In such service this small trailer, with its box body having suitable compartments and racks, provides a convenient place for splicer and helper to keep their tools, sleeving, solder, paraffin, etc. At night the body is locked, a lantern is secured in a screen holder on top, and the unit can be left on the job.

For very short distances between splices the men may move the trailer along the street by hand. For moves of greater distance it is either trailed behind a vehicle or, for long hauls at usual road speeds, it may be carried in a truck. This trailer weighs approximately 420 pounds and ordinarily carries a load

of about 450 pounds. There are many hundreds of these splicers' trailers in service in the Bell System.

Heavy Duty Trailers for Reels of Cable, Etc.

It is evident that special provision must be made for transporting reels of cable, which ordinarily may weigh up to 6,000 pounds each. One type of trailer for this work (Figure 5) carries the reel on a spindle with the design so arranged that the balance will always be slightly heavy toward the front or tongue end.

This cable reel trailer is loaded by placing the spindle through the center of the reel, raising the trailer tongue by hand until the back lips of the saddles hook under the spindle ends, and then pulling the tongue down with the truck winch rope. As the tongue is lowered, the spindle rolls forward on the saddles into the front brackets, where it is pinned.

Reels up to seven feet in diameter and 37 inches wide can be handled by this trailer, which weighs about 2,700 pounds. With this equipment the cable can be pulled from the reel while it is supported on the trailer spindle, thus obviating the necessity of unloading it and swinging the reel on a spindle supported by means of jacks.

By removing the detachable saddles and adding the pole bolsters, which also can be quickly attached or detached, this unit can be easily changed into a pole trailer (Figure 6). Since it has a non-extensible tongue, one of the poles in the load is used as a tongue.

For delivering the very heavy reels of armored cable on cross country jobs away from the highway, special trailers have been developed which are of heavier, stronger construction than the highway trailers and which have special provision for supporting the loads over soft ground. The so-called "Winch Loading Trailer" for this purpose (Figure 7) is loaded by means of a hinged yoke which is lowered back from the trailer by the winch rope until it rests against stops so that the steel rope

slings can be hooked under the ends of the cable reel spindle. Then the winch rope pulls the yoke forward, swinging the reel free of the ground (Figure 8). By continuing to pull the yoke forward (Figure 9), the spindle slides up the guide until it can be locked at the top by means of hinged hooks.

It will be noted that two pairs of dual rubber tires are used on each bogie or wheel carriage supporting this trailer. The tires are so spaced that, where required by very soft ground, a steel track of hinged pads can be thrown over both dual wheels, with centering lugs between the dual tires. These are detachable and are not shown in the pictures.

Some tractors used in delivering reels of cable off the road do not have winches. For such a condition, the traction loading trailer (Figure 10) can be used. This type is sometimes referred to as a "Jack-Knife Trailer."

In loading this trailer, one of the caterpillar tracks is pinned so the wheels will not move, and the tractor is backed up, throwing the trailer frame and spindle hooks back and down so that the reel spindle can be caught. The tractor then moves ahead slowly (Figure 11), thus raising the reel until the jackknifed trailer frame is pulled forward into the traveling position (Figure 12) and locked. The tongue is extended when a reel happens to rest in a hole, thus permitting the lowering of the spindle hooks quite low to pick it up.

The winch loading and traction loading trailers, as shown, weigh about 4,500 and 4,400 pounds respectively. They carry reels of cable weighing up to 10,000 pounds each, and measuring 46 inches wide by seven feet in diameter. These trailers have also been used to advantage in delivering heavy loading pots by hanging them from the cable reel spindle.

Truck Power-Take-Offs and Power Winches

The most frequently used device of power equipment on the truck is the power winch, and the simplest winch installation is the single drum type (Figure 13). The illustration

shows the winch mounted on the chassis just before the truck body is installed. The cast steel winch drum upon which the steel winch rope is wound may be connected to the shaft by a jaw clutch, so that when desired the drum can be permitted to turn freely on its shaft, as in paying out the winch line. When the clutch lever at one end of the drum is pushed in one direction it engages the clutch and in the other direction it releases the clutch. Then at a farther position this lever action puts a brake upon the drum so that it can be prevented from spinning too fast if rope is being pulled off.

By different gear reductions and engine speeds, almost any desired rope speed can be secured, from 20 to 270 feet per minute. The winch will exert a line pull of 10,000 pounds, or even more for a short time. The heavy rope pulls introduce very great pressures between the driving worm and wheel (Figure 14), located in the case at the end of the drum. In fact, the pressure between these gear teeth may exceed seven tons at times because the teeth are closer to the shaft than the rope leaving the drum. In order satisfactorily to withstand these conditions, the gears and worms are very accurately cut from high grade especially selected bronze and steel respectively, and they run in a special extreme pressure lubricant.

At the end of the worm shaft away from the sprocket, there is a safety device in the form of an automatic brake (Figure 14) which works when the drum rotates in the reverse direction only and which will not permit the dropping out of control of a suspended load on the winch line due to overhauling of the gears. This is a very important feature in erecting poles and handling cable reels.

As viewed from beneath the chassis (Figure 15), the drive for this particular winch comes from a power take-off attached to the side of the truck transmission. A propeller shaft leads from the power take-off to an auxiliary transmission under the winch frame. From a sprocket on the shaft leading out of the auxiliary transmission a silent chain transmits the power

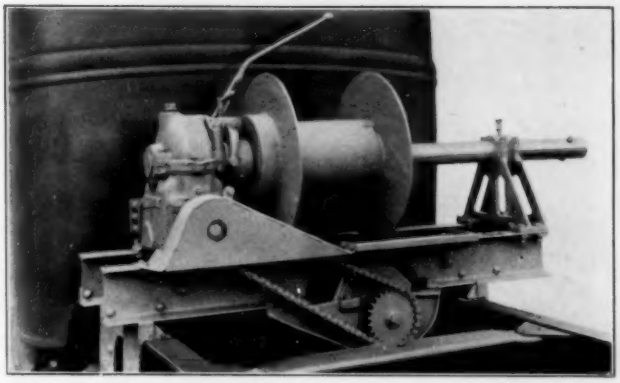


FIG. 13. SINGLE DRUM POWER WINCH "SL12-RRC-82," WITH DRUM CLUTCH AND BRAKE.

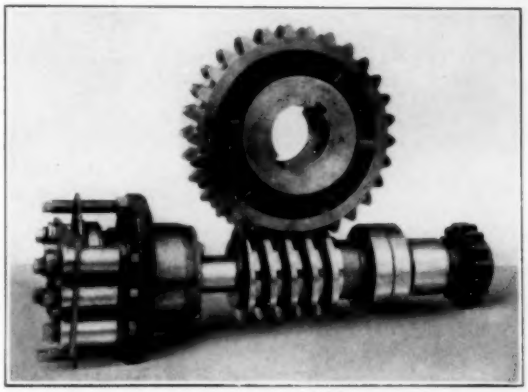


FIG. 14. OPERATING MECHANISM INSIDE THE POWER WINCH.

FIG. 15 (BELOW). VIEW OF WINCH, POWER TAKE-OFF, AND AUXILIARY TRANSMISSION, FROM BENEATH.

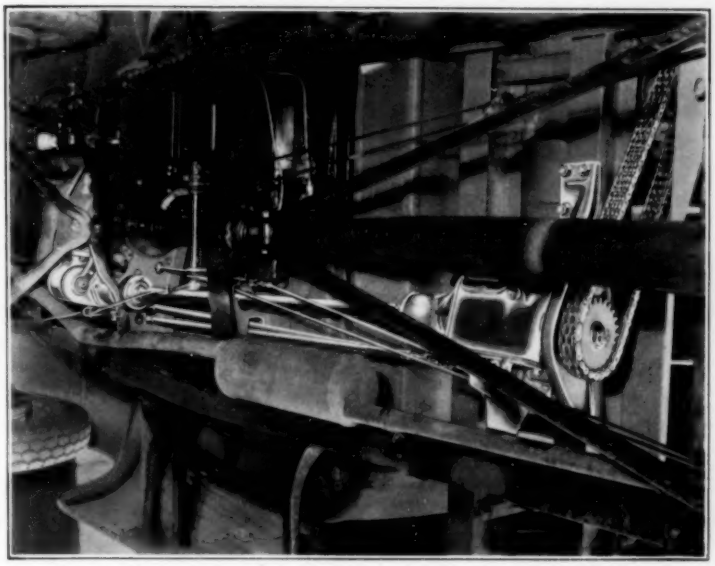


FIG. 16. DOUBLE DRUM POWER WINCH "LFRC–82–LFR."

FIG. 17 (BELOW). "HC" EARTH BORING MACHINE READY TO START A HOLE.

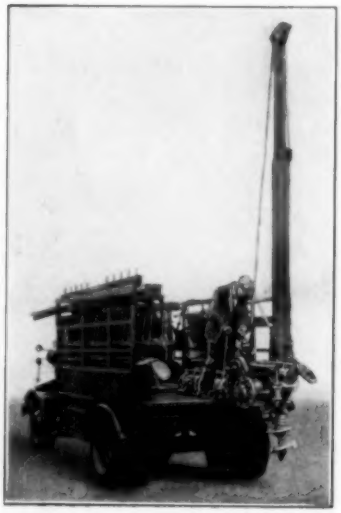


FIG. 18 (ABOVE). ERECTING 40-FOOT POLE WITH TELESCOPING DERRICK ON "HC" EARTH BORING MACHINE. (NOTE HIGH TRACTION TIRES ON FOUR WHEEL DRIVE TYPE OF TRUCK.)

FIG. 19. DERRICK TELESCOPED AND BORING MACHINE LOWERED TO TRAVELING POSITION.

FIG. 21. DROP WIRE REEL ON "LI" BODY.

FIG. 22. LADDER PLATFORM IN SERVICE.

FIG. 23 (BELOW). LADDER PLATFORM IN CARRYING POSITION ON 1½ TON "LC-104" TRUCK.

up to the winch. A lever in the cab selects the desired gear combination in this auxiliary transmission.

For some conditions of operation, as for instance in handling a pole derrick with both a boom line and a fall line, a double drum winch (Figure 16) is required. Each drum is driven independently. A complete double drum winch, together with its power take-off, drive chains, mounting brackets and levers, adds about 970 pounds to the weight of a truck. For the single drum winch which is illustrated, this figure is about 650 pounds.

Equipment for Setting Poles

Where a considerable amount of pole work is to be done, the use of the latest type heavy duty earth boring machine is advantageous (Figure 17). A truck of the four wheel drive type using high traction tires on all wheels can reach almost any location where it may be desired to dig the hole and set a pole. Ordinarily the actual digging of a six foot hole 20 inches in diameter requires two or three minutes.

The new telescoping tubular derrick (Figure 18), which is an integral part of the machine, can be extended or telescoped by power controlled by the earth boring machine operator. Also, the usual power operated leveling worms of the machine are used to tilt or straighten the derrick either sidewise or front and rear. These features are very convenient when erecting poles into wire lines or among tree limbs.

When it is desired to travel a short distance between pole holes, ordinarily the derrick is telescoped and carried in the erected position. However, when moves of any considerable distance are contemplated, the derrick is telescoped by power and then one of the power operated leveling worms lowers the machine into the truck body (Figure 19).

The earth boring machine mechanism as it is attached to the truck (Figure 17) consists of a tubular case with suitable brackets for the attaching bolts. At the rear end of the tube is an intermediate case connected to it by a swivel joint. At-

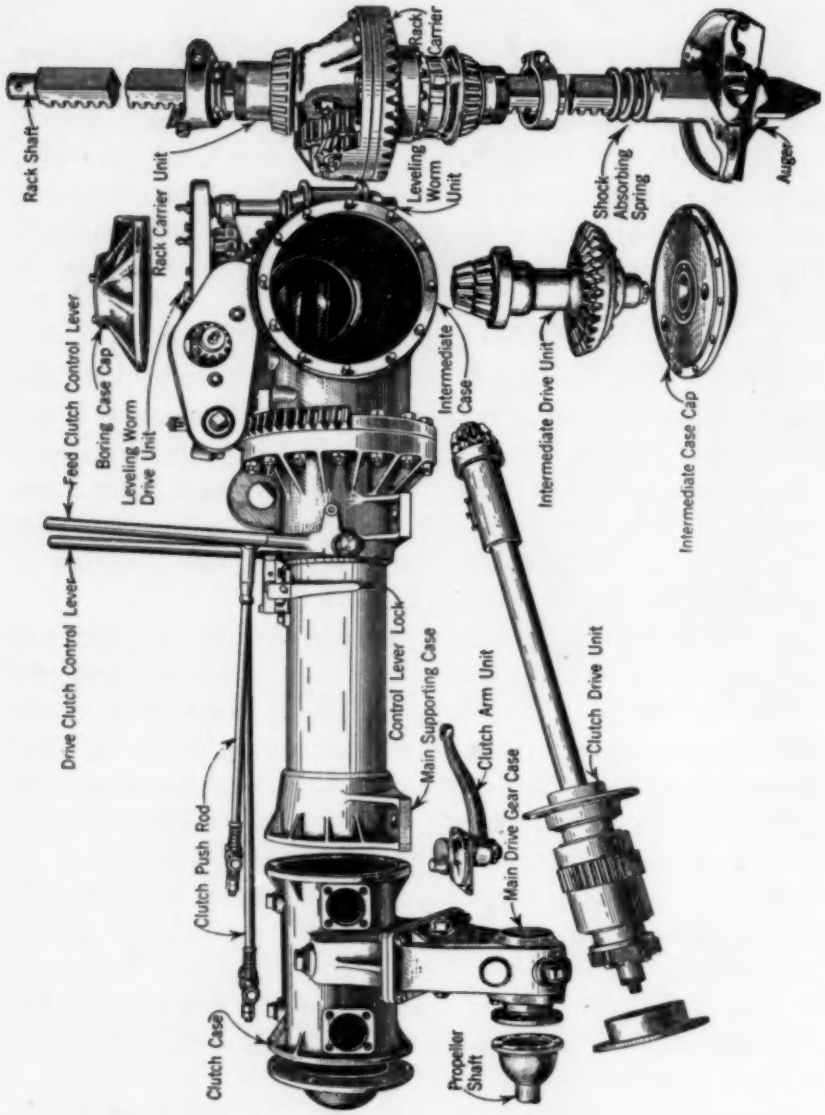


FIG. 20. "EXPLODED" VIEW OF "HC" EARTH BORING MACHINE; DERRICK NOT SHOWN.

tached to one side of the intermediate case by another swivel joint is the boring head case. The operation of these two swivel joints by power accomplishes the leveling of the boring head case so that the hole can be dug vertically regardless of any slope upon which the truck may be standing.

The mechanism of the boring unit, which is shown in an exploded view in Figure 20, is carried inside the three above mentioned cases upon anti-friction bearings throughout. All control for boring, and for raising and lowering the auger, is through the two operating levers, each of which connects with a clutch and a brake. Power from the clutches to the auger rack shaft is transmitted by two lines of shafts consisting of solid shafts working inside quill or hollow shafts, pairs of bevel gears being used at each point where there is a change in direction. The inner or solid shafts are responsible for rotating the auger and the quill shafts for raising and lowering it.

The complete truck, chassis, cab, body and earth boring machine weigh about 14,500 pounds. The weight of the boring machine mechanism alone is about 3,000 pounds.

Reels for Drop Wire

Thousands of half ton cars, somewhat lighter vehicles than those discussed thus far, serve men who use insulated drop wire for making connections from poles to buildings. These cars are equipped for carrying a drop wire reel (Figure 21), which can be used on the car or on the ground for paying out or winding coils of wire. These reels are convenient to handle, as they weigh only about 30 pounds, and they have an automatic brake to prevent the spool from over-running and snarling the wire.

Aerial Work

Recently much interest has been shown in, and a considerable amount of experimental field work done with, a device called the ladder platform (Figure 22). This consists of an espe-

cially designed, very strongly built extension ladder having a platform near its top where one or two men can work. The ladder is always carried and supported in the truck. When in use, its bottom is pinned to the floor in a swivel joint, so that before the man ascends he can readily swing the ladder around to any position on the sides or back of the truck, where it is supported by a strong steel ring permanently mounted on the truck body. The ladder is also arranged so that it can be extended or shortened by one man.

This device is used for maintenance work, such as inspection and repair of aerial cable, tree trimming, etc. When the job is such that the truck is moved with the workman on the platform, a telephone connection is ordinarily maintained between him and the driver to insure coördination.

To take down the ladder for moving long distances, it is first telescoped down to its shortest length and swung around to rest on a straight bar on the front side of and below the ring. Then the pivot pin is pulled from the floor and the ladder balanced on the cross bar, after which it is lowered to a horizontal position (Figure 23).

It is planned to use the ladder platform with light maintenance trucks of 1½ tons capacity, such as that illustrated in Figure 23. The permanent ring adds about 200 pounds to the weight of the standard body and the ladder with its platform weighs about 214 pounds.

In all the designs of automotive equipment for telephone outside plant use mentioned above and the many others in this same general class, particular attention has been paid to safety of operation as well as convenience for the men and economy in performing the work. It is needless to say that the use of these and the many other similar items of equipment greatly expedites the work, which is of distinct value in the day to day gang performance but is doubly important during times of emergency.

When automotive equipment is transferred from one section

of the country to another, as is often necessary in clearing up storm damage, etc., it is very advantageous to have uniformity of equipment, so that the specially organized forces can function immediately in accordance with the methods followed in their usual work. Also, of course, the large degree to which the equipment is now uniform leads to the purchase of a relatively large volume of each item, so that purchasing advantages are realized, as well as improved manufacturing arrangements, more satisfactory inspection of the different types of units before they leave the factories, and more prompt availability of the various kinds of new equipment as the requirements for them arise at any points among the field forces throughout the country.

T. C. SMITH

A Northwest Winter—and the Telephone

Editor's Note:

The following report was compiled at the headquarters of the Northwestern Bell Telephone Company under the heading, "A Brief Resumé of the Effect on Telephone Service of the Abnormal Weather Conditions prevailing during the Winter of 1935–1936." The document was written for internal circulation only, but since it constitutes an interesting revelation of telephone operating conditions, and of the operating point of view, during a Northwest winter, it is printed here with the thought that all Bell System readers will take pride in the record.

"THE coldest winter weather in its history" was the announcement of the Federal Weather Bureau regarding the extended period of subnormal and subzero weather prevailing in our territory from December 24, 1935, to the latter part of February, 1936. This record-breaking situation, with temperatures below zero for consecutive periods of from 25 to 30 days and with lows of 34 degrees below zero in Iowa, 35 in Nebraska, 52 in South Dakota, 55 in Minnesota, and 56 in North Dakota, was accompanied by frequent snows and high winds, these causing drifts in places of 25 feet or more which, in spite of all the efforts of the railroad and highway crews, slowed up and at times completely paralyzed all forms of transportation, leaving many communities and families isolated. The snowfall during the period varied from 2 feet to 5 feet throughout the territory. On many days the combined conditions of cold and blinding blizzard rendered it quite dangerous to attempt cross-country travel by any means of locomotion.

Naturally such a situation affected the business and social activities of the entire population and resulted in the most severe and prolonged test of our facilities and service that has ever been experienced. Peak days on which the community use of telephones was more than double the normal volume

were the rule rather than the exception, while toll business during the worst period of the winter ranged from 25 to more than 150 per cent above normal.

Effect on Telephone Facilities and Service

Our outside plant is well designed for these conditions and in an excellent state of upkeep, as is evidenced by the fact that practically the only type of plant failure was wire breaks due to extremely low temperatures. This type of trouble is always experienced with low temperature but is usually not serious. In spite of the fact that this cold-weather wire-break trouble has been studied for many years and has been minimized by certain refinements in design, no economical means of complete elimination appears to be available. The strain placed on wire during an extremely cold period might be illustrated by the fact that a 130 foot span having 14 inches of sag at 100 degrees above zero will contract until the sag is about 3 inches at 40 degrees below zero. Defects in the wire from wear or other causes are likely to result in breaks when the additional strain is applied.

Out of a total of 4,500 toll circuits in the plant, less than 10 per cent were out of service, due to this cause, for comparatively short periods during the days of the most severe temperature and wind conditions. These troubles, fortunately, were not concentrated, and only a few of the smallest communities at isolated points served by only one or two circuits were without telephone service for more than one day.

While troubles in connection with rural station service, both owned stations and service station companies, were not abnormal, the effect of failures of these lines frequently cut off families from any form of communication.

In many communities, the central office equipment, particularly the manual equipment, in spite of additional operators,

etc., was unable to handle the traffic as promptly as usual because of the abnormal number of calls.

In the dial cities, there was evidence of prolonged overloads which were noticeable to the customer by failure to obtain the dial tone and by encountering busy trunk groups. In Des Moines, additional trunks and rearrangements brought some relief. In Minneapolis, spare switchboard positions were cut into service where available, and interoffice trunk groups were enlarged both in Minneapolis and Omaha.

Traffic to tourist bureaus and street car, bus, taxi, railroad, and coal companies was probably the heaviest of any one type of business. In Minneapolis, the Yellow Cab Company was flooded with calls for a period of several days. In some cases, because of busy lines to schools, the operators helped by furnishing information as to which schools were closed.

In only one or two instances were peg counts of local use of telephone equipment taken on the day of the heaviest traffic. However, the record of the high recorded day at representative exchanges, as tabulated on the following page, furnishes some information as to increased traffic, of which Sioux City, Iowa, taken on February 7, is probably the most representative of the peak loads recorded.

Except for a somewhat slower answering time, due to overloads, we have no evidence of where telephone service failed to serve the purpose for which it was designed.

It is difficult to estimate how many millions of dollars of additional investment would be required to maintain the normal speed of the telephone service in emergencies of this kind. Beyond anything that we could do with regard to adding facilities in our own plant, there would still be the necessity of customers providing themselves with much additional service. For example, the railroads and coal companies, the newspapers, highway departments, etc., would need to have a large increase in their telephone facilities and personnel to maintain a normal service during such periods as they have just experienced.

Exchange	Local Traffic			Toll Traffic		
	Normal	High Recorded Day	Per Cent Increase	Normal	High Recorded Day	Per Cent Increase
Des Moines, Iowa	316,427	439,779	39	2,750	4,782	74
Cedar Rapids, Iowa	111,279	147,317	32	1,500	2,490	66
Sioux City, Iowa	140,099	316,513	126	1,150	1,791	56
Mason City, Iowa	37,238	55,420	49	850	1,324	56
Waterloo, Iowa	66,278	79,815	20	1,000	1,800	80
Davenport, Iowa	105,000	142,003	35	850	1,469	73
Omaha, Nebraska	430,000	735,000	71	2,700	3,874	43
Grand Island, Nebraska	26,000	51,225	97	385	575	50
Norfolk, Nebraska	14,850	28,000	90	440	670	52
North Platte, Nebraska	15,524	27,730	79	200	289	45
Sioux Falls, S. Dakota	70,000	133,000	90	825	1,285	56
Minneapolis, Minnesota	911,580	1,045,416	15	3,650	4,640	27
St. Paul, Minnesota	512,000	595,000	16	1,550	2,167	40
Duluth, Minnesota	144,000	204,306	42	725	852	18
Fargo, North Dakota	84,071	100,306	19	629	878	39
Grand Forks, North Dakota	41,188	50,845	23	326	478	46

Employee Performance

Meeting this emergency taxed the initiative and morale of the organization severely. The alertness and ingenuity of the District and other supervisory people were continuously demonstrated in their promptness in sensing the rapid increase in demands and in planning and assembling forces as well as in meeting many specific difficulties. The spirit shown by the operators, installers, repairmen, and other groups was excellent. Many unusual problems were encountered and met with ingenuity. Ex-employees whom we occasionally hire responded to the needs of the service with the same spirit as those regularly employed. The regular employees, without exception, willingly gave up personal plans and scheduled days off to help meet the conditions by working long hours at top speed as the occasion might demand.

In many cases transportation was provided by the members

of other departments. Taxicabs and cars rented from "Drive-It-Yourself" companies were used extensively. When other means of transportation failed, the employees frequently walked in order to be at work on time. Many operators arranged to stay with friends nearer the offices, or their supervisors provided sleeping facilities in or near the exchange. One outstanding example of devotion to duty was the case of an operator in Sioux City who, on the morning of February 8, reported for duty after walking two miles against a 38-mile wind in a temperature of 18 degrees below zero.

The efforts of our Plant forces were directed toward giving preference to toll line troubles on circuits leading to towns that were isolated. This was done under the most severe conditions. The general use of motor vehicles and equipment had to be abandoned and our forces resorted to other means of transportation, such as snowmobiles, skis, snowshoes, railroad trains, railroad speeders, horses, and, in two cases, an airplane. Two types of snowmobiles were used, one type propelled by a chain track similar to an army tank and the other provided with skis in front and rear with motive power supplied by an engine equipped with an airplane propeller. In North Dakota, officials of the Great Northern and Northern Pacific Railway Companies extended every practicable aid to us in clearing trouble. They permitted the use of their section men and speeders in every case where we asked for such help.

In many of the smaller exchanges, especially magneto, where the local forces realized that some of the rural subscribers were more isolated than others, daily tests of these circuits were made. Where it was determined that trouble existed or that a portion of the customers on any one line were out of service, the last customer reached was asked to check the remainder of the stations and make temporary repairs of broken wire, with the understanding, of course, that proper remuneration would be paid for the time they spent on the work.

However, in spite of the use of all other possible means of transportation, much of the trouble necessitated walking for considerable distances. In one instance a repairman walked 19 mile in one day to clear toll line trouble with temperatures 15 below zero and a strong wind. In another case two men were forced to spend most of Christmas day in a small town consisting of a grain elevator and a few other buildings. In several cases workmen walked from 10 to 12 miles a day through deep snow and traveled more than 60 miles on foot during a calendar week.

While the ingenuity of employees in getting to and from work and in clearing trouble on rural service and circuits leading to towns that were isolated were probably more thrilling, the performance of the forces in carrying on the routine work of the exchange, the handling of the central office equipment under tremendously overloaded conditions, and the installing of the greatest net gain in stations during any similar period since 1920 provided an accomplishment equal in performance and worthy of the highest praise and commendation.

In all of the above activities and hardship, every effort was made to protect the health and safety of the employees, it being of particular interest that no serious cases of accident or illness developed during the period.

Uses Made of Telephone Service

With rail and highway transportation hampered and mail service badly crippled, telephone subscribers were forced to rely upon the telephone considerably more than under normal conditions. In many cases, telephone service became the only substitute for all these other public services. It was the one service which enabled families, business, government, and communities to maintain contact. The state highway commissions and county officials used it extensively in connection with their efforts to open highways. The railroads used it in connection

with the clearing of snowbound rights-of-way. Train crews engaged in clearing rights-of-way reported frequently from the nearest available telephone. Train dispatchers checked the progress of these crews by calling farmers along the railroad. In a number of exchanges, it was extensively used for calling the homes of children attending consolidated schools, informing the parents not to start their children out, etc. On the days when the school busses were running, many calls were made to see if they arrived safely.

Farmers who were able to get into town called their neighbors to see if there were any supplies they could bring to them in order to save them a trip during the bad weather. Merchants in towns would call the farmers and make deliveries of coal and other commodities by traveling along main highways, with farmers meeting them at specified points to obtain supplies. Travelers in blocked trains and automobiles sought shelter in nearby homes. Telephone calls informed their families of their safety.

At Corydon, Iowa, on Saturday, February 8, the day of the worst blizzard, a water main broke and the entire town was deprived of water for three days. The telephone was used to inform the people of this situation and when water would again be available.

In communities where there was a shortage of bread, milk, or other commodities, dealers used the telephone to locate sources of supply. The C. C. C. Camp located near Camp Brook, South Dakota, placed an emergency call for food. Fort Meade and the Highway Maintenance Department at Sturgis organized caravan of snowplows, trucks, and men as a rescue party to carry food to this camp. Similar means were used to reach other inland towns located in the northwestern part of the state.

Stores experienced a great increase in orders by telephone. Many stores put on extra help to answer telephones and make deliveries.

A number of cases were reported where farmers who had discontinued their service for a considerable period, but where the telephones were still in place in their residences, reconnected their own telephones and called the local manager explaining what had been done and of their intent to come in and arrange for the reëstablishment of their service as soon as possible.

Snowbound homes and communities reported cases of critical illness by telephone so that snowplows and highway crews could open the roads and bring aid. Physicians found it difficult, and in many cases impossible, to reach their patients and gave instructions by telephone for the care of the sick. Some cases which are typical of the general conditions may be briefly mentioned as follows:

An ambulance carrying a patient from Persia, Iowa, to Council Bluffs at night was stalled south of Underwood. The driver went to the nearest farm house, called the operator at McClelland, who summoned farmers to shovel a path for the ambulance, which then went on to its destination.

The son of a farmer living nine miles west of Pocahontas, Iowa, became ill with an acute case of appendicitis. The telephone in that home was a service station out of Verina but was out of order. The farmer walked to a neighbor who had Pocahontas service and from there called a doctor, who was unable to reach the farm but gave instructions as to treatment over the telephone. The next day the boy's condition was much worse. Neighbors who had kept in touch with the family called for a snowplow, which was able to proceed within a quarter of a mile of the farm house. The boy was carried to where the road was open and in a neighbor's car, with the snowplow breaking the trail, they reached Gilmore City and from there Fort Dodge, where an emergency operation was performed. The distance traveled was only 50 miles but eleven hours were required for the journey.

A doctor at Valley Junction, Iowa, had three rural patients

who could not be reached by the road and had to be treated by telephone. The doctor states that the telephone was the only means of contact between these people and the outside world.

At Virginia, Minnesota, the night operator received a call for a doctor and, sensing something unusual, she called for several until one was found. When the doctor arrived he found four people overcome by escaping gas from a frozen gas main; a pulmotor was obtained, and the victims saved.

The operator at Grand Marais, Minnesota, succeeded in summoning help for a stricken family 70 miles north of that town. A trapper living on the Canadian side with his family walked 10 miles to the nearest telephone and asked the operator to send help to his home. He reported that one child was dead and the rest of the family seriously ill. The operator communicated with Canadian officials and obtained help from that source.

The manager at Howells, Nebraska, was advised by a doctor that the telephone of a farmer residing seven miles in the country was out-of-order and that one of the children was seriously ill with scarlet fever. The manager walked 14 miles to repair the telephone, the roads being covered with snowdrifts from four to eight feet in depth.

During the storm of February 3, the towns of Springfield and Gann Valley, South Dakota, were isolated as far as long distance service was concerned. The trouble was reached and repaired by using a saddle horse for transportation. At Gann Valley there was an epidemic of measles and no doctor was available. The telephone service enabled the people of these communities to communicate with doctors in neighboring towns.

Eight cases are on record where babies were brought into the world by following instructions given by doctors over the telephone. A resident just outside of the city limits of Omaha called their family physician on Saturday night, February 8, regarding a confinement case. The doctor's car became

stranded in snow several blocks from the home and he could not make his way there even on foot. He backed out and drove into town, from where he telephoned the home. The father, having assisted the doctor at the births of three previous children, was given specific instructions by telephone, which he carried out successfully alone. The doctor was unable to get to the home until Monday but he kept in touch by telephone and when he did arrive he pronounced everything satisfactory with regard to the birth of the baby girl.

On account of the deep snow making it impossible to get through, a doctor at Atkinson, Nebraska, gave instructions over the telephone for the handling of three confinement cases.

Other similar situations were reported from Faribault, Minnesota; Wayne, Nebraska; LeMars, Iowa; and Canton, South Dakota.

Public Reactions, Both Critical and Commendatory

Of all the expressed reactions from the public, it is difficult to pick out any of a definitely unfavorable nature; there were hundreds of a most favorable character. At a few exchanges, principally in the larger towns where the operators were handling a peak load of calls, some criticisms were received to the effect that service was slow.

In Des Moines, after experiencing for several days the enormous overloads of local calls with resultant lack of promptness in completion of calls, it was decided to interview personally several hundred of our customers. We chose those who had contacted the Repair Department concerning delays, busies, no dial tone, etc., and of the nearly 500 interviewed substantially all were interested in our problem and appreciated our contacting them and there was not a single case of serious dissatisfaction with the service. Similar programmed interviews with large groups of subscribers in other exchanges where delayed service developed met with the same results.

Public reactions were in general favorable. Newspapers gave considerable space to the weather and to its effect on telephone service. Several papers ran suitable feature articles on the latter. Advertisements were inserted in papers where appropriate. All of these apparently gave telephone users a tolerant understanding of the situation and as a result the service was better than they expected.

A doctor, who has always been hypercritical of the service, called the Chief Operator to express appreciation of the fine service under trying circumstances.

Other comments received at various exchanges may be quoted as follows:

> "I have received more value from my service during the past few weeks than I pay for it for an entire year."
>
> "Our telephone was the only contact with the outside world for over a week. I cannot see how anyone can get along without one."
>
> "Telephone instructions received from the doctor who could not reach my farm were responsible for saving the life of my daughter."
>
> "If it had not been for the help of your agent, I would have lost my wife and three children."
>
> "We don't know what we would have done if it had not been possible to secure help by telephone."
>
> "First aid instructions received by telephone saved my hands from amputation after they were badly frozen."

Many compliments and thanks have been received for the services rendered and much consideration has been shown the operators.

One banker who sensed the situation during the December 24 storm gave orders that all use of the telephone in the bank must stop during the storm except in cases of extreme necessity.

On the evening of February 7, during the height of the most severe blizzard in Grand Island, Nebraska, a number of men

from the Episcopal Church called at our Grand Island office and were shown through the building. All of these men were high in their praise of the service, and especially were they complimentary relative to the manner in which the girls handled the terrific volume of calls while these men were observing them at work.

At Litchfield, Minnesota, when one of our operators offered to pay a taxi driver for taking her home, he refused payment, saying " the telephone operators have done so many good things for us during this stormy weather that I would not think of accepting payment from you for a ride, or from any of the operators."

Another interesting example of willingness on the part of the forces to volunteer help to others in an emergency was obtained from Mr. Bayard H. Paine, one of the State Supreme Court Judges of Nebraska, who called at our office immediately following a severe blizzard. He informed us that while on his way to Grand Island, Nebraska, during the storm his car ran off the road into a ditch and a passer-by agreed to send him a wrecking car from the nearest town. When this car arrived he found that it was a light wrecking car. He stated that after considerable effort, covering a period of two hours, during which time the wrecking car became stalled in the ditch also, a large telephone truck came along. Mr. Paine called attention to the fact that in spite of these telephone men being out on an emergency trouble, the big truck stopped alongside his car, some of the men jumped out, looked over the situation, pulled out a cable from inside the truck, and without any ceremony hooked the cable on the front end of the wrecking car and pulled both cars out of the ditch up on to the road. Two of the men jumped out of the truck, unhooked the cable, placed it in the truck, waved their hands, and the truck went on about its work. Mr. Paine marveled at the fine coöperative spirit which prompted these men, busy with their own emergency re-

pair work, to stop and assist an unfortunate person such as he, and the spirit in which they did so. He expressed regret that it was not possible for him even to thank them, as they merely waved their hands and left without thought of compensation or reward for their service.

Our manager at Buffalo, Minnesota, repaired a service station line containing seven stations when he learned that the lineman was ill and unable to take care of it. The subscribers expressed their gratitude for giving them this service when it was so badly needed.

The manager at Cambridge, Minnesota, repaired a broken service station line when he found that the lineman was snowed in. Many other instances of assistance to service station companies were evident throughout the period.

Conclusion

The alertness and ingenuity of employees and the splendid spirit shown by them in maintaining throughout this trying situation a high quality of continuous service is impressive. This is particularly true when, in reviewing the various reports, it is realized that this performance was not local to any one community or area but was typical of all communities and all areas within the Company's territory, including the territories of subsidiary companies.

While naturally pleased with such an accomplishment, the Company's organization has recognized the importance of surveying and recording in detail any equipment and operating failures, interruptions or delays, with the view of minimizing the effect of similar conditions through refinements, adjustments or expansion where sound administrative analysis indicates that it is appropriate.

Notes on Recent Occurrences

PRESENTATION OF JOHN J. CARTY MEDAL AND AWARD FOR THE ADVANCEMENT OF SCIENCE

IN connection with the presentation on November 17, 1936, by the National Academy of Sciences of the John J. Carty Medal and Award to Dr. Edmund Beecher Wilson, Professor Emeritus of Zoölogy, Columbia University, the following presentation address was made by Dr. Frank B. Jewett, Vice President of the American Telephone and Telegraph Company:

MR. PRESIDENT: In connection with presenting Dr. Edmund Beecher Wilson to you for receipt of the John J. Carty Medal and Award for the Advancement of Science, voted to him last spring by the Academy, it is appropriate that a word both as to the history of the medal and award and Dr. Wilson's qualifications for it should be made. I am happy that it falls to my lot as Chairman of the Carty Medal Committee to make these few remarks.

The late General John J. Carty, in whose honor this medal and award were established, was for many years a distinguished member of the National Academy of Sciences. His major activity throughout his active life was concerned with the development of electrical communication. At the time of his death on December 27, 1932, it can be said without fear of contradiction that he was recognized to be the most distinguished communication engineer in the world. This distinction had long been his and when, on June 30, 1930, he retired for age from active service as Vice President of the American Telephone and Telegraph Company, his associates in the Bell System sought for some appropriate way in which to signalize their esteem for him and for his contributions to science and engineering. Recognizing as they did the wide and scholarly

sweep of his intellectual and scientific interests and his deep and abiding faith in the value of the National Academy of Sciences as a powerful instrumentality for the advancement of science in the United States, they decided that nothing could be more appropriate nor more pleasing to General Carty than the establishment of a perpetual medal and award in the Academy to be named for him.

The result of this decision was that the Directors of the American Telephone and Telegraph Company, acting for themselves, the stockholders of the Company, and the employees, all of whom recognized their great debt to General Carty, gave to the Academy the sum of $25,000 to be held in trust, with the income available periodically for the bestowal of a gold medal and a monetary award. In addition to this, General Carty's immediate associates in the management of the American Telephone and Telegraph Company, as a token of their particular admiration and esteem, arranged for the design of the medal and the making of the dies needed for striking it.

In order that with the passage of time the medal and award should achieve a real distinction, and because of the catholicity of General Carty's interest in the whole domain of science, the donors in their Deed of Gift specified only two major requirements. The first and lesser of these requirements was that the medal and award should not be bestowed oftener than once in two years. As a part of this condition it was specified that with every award the net accumulated income since the time of the last award should be given to the recipient along with the medal and certificate.

The second and major condition specified by the donors was that the award should be to an individual for noteworthy and distinguished accomplishment in any field of science coming within the scope of the charter of the National Academy of Sciences, and should be either for specific accomplishment or for general service in the advancement of fundamental and applied science; and further, that there should be no limitation placed on the individual sought to be honored by virtue of race,

nationality or creed. The method of selecting the candidates to be voted on by the Academy and the method of taking such vote was left entirely to the discretion of the Academy.

Under the conditions of this Deed of Gift, the Academy is assured at all times of complete and untrammeled freedom to bestow this particular honor periodically on anyone anywhere and for any achievement in the field of its present or future interest, whenever in its judgment such bestowal is appropriate.

Thus far since its establishment the medal has been bestowed but once, and that through unanimous vote of the Academy on General Carty himself. Fortunately, this evidence of esteem was made before General Carty's death and was a source of the deepest gratification to him. Unfortunately, presentation of the medal had to be made posthumously.

On this occasion the action of the Academy last spring was on the unanimous recommendation of the Carty Medal Committee. This recommendation was made after long and painstaking consideration. In presenting Dr. Wilson to you I feel I can do no better than to quote from the report of the Committee as follows:

> " In recent years, Professor Wilson has stood preëminent in the field of zoölogy, and the influence he has had on two generations of biologists is of a very high order. His individual researches on experimental embryology are classical, and his papers on cytology have been fundamental. His great book, ' The Cell in Development and Inheritance,' has perhaps influenced subsequent biological thought more than any other book produced in this country.
>
> " In arriving at its present decision to recommend Professor Wilson, the Committee has been guided by the terms of the Deed of Gift, which as they relate to the recipient's qualifications read as follows:
>
> > ' The award may be either for specific accomplishment in some field of science, or for general service in the advancement of fundamental and applied science.'
>
> " In view of his outstanding contributions, the Committee has no hesitancy in suggesting that Professor Wilson's selection is appro-

priate both as to specific accomplishment and general service, and we, its members, believe that every consideration points to him as one eminently qualified to receive the Carty medal."

It is now therefore my very great pleasure to present Professor Wilson for the Carty Medal and Certificate, and its accompanying Award, which in this case I understand to have a value of $3000.

GOLD MEDAL IS AWARDED BELL TELEPHONE LABORATORIES

THE award of a gold medal for 1937 by the American Institute of the City of New York to the Bell Telephone Laboratories has recently been announced. The gold medal, given annually by the American Institute in recognition of outstanding accomplishment in research, was awarded to the Bell Telephone Laboratories "for researches in electrical science which, applied to communication, have promoted understanding, security and commerce among peoples by transmitting human thought instantly throughout the world." The medal will be presented at a meeting of the Institute to be held on February 4, and will be accepted by Dr. Frank B. Jewett, President of the Laboratories. The American Institute of the City of New York was incorporated in 1828 for the purpose of "encouraging and promoting domestic industry in this State and in the United States."

RADIOTELEPHONE SERVICE IS OPENED TO LINER ON THE PACIFIC RUN

SHIP–TO–SHORE telephone service, which has been available for several years with a score of liners on the Atlantic, was extended to the Pacific Ocean recently when service was opened between this country and the steamship Chichibu Maru of the Nippon Yusen Kaisha (Japanese Mail Steamship Company).

The service to the Chichibu Maru is available throughout the ship's voyage, which touches Honolulu, Yokohama, Kobe, Shanghai and Hong Kong, and to all Bell and Bell-connecting

telephones in the United States, Canada, Cuba and Mexico. The ship is 17,500 tons, one of the three largest ships in N. Y. K.'s fleet.

Contact with the Chichibu Maru utilizes the radio facilities at Dixon and Point Reyes, Cal., Bell System short wave transmitting and receiving stations respectively. These stations are already used for telephone service with Hawaii and the Orient, and for the past five years have been used in giving telephone service with the Empress of Britain, Canadian Pacific liner, during part of her annual round-the-world cruise.

FIRST DIRECT RADIOTELEPHONE CHANNEL TO CONTINENT OPENED ON DECEMBER 1

THE Bell System made its first direct contact with continental Europe on December 1, 1936, when a short wave radio telephone circuit was opened between stations of the American Telephone and Telegraph Company in New Jersey and stations of the French Ministry of Posts, Telegraphs and Telephones near Paris.

Before the opening of the new radio link, service between Bell and Bell-connecting telephones and those in France was handled through London. Service was originally established with Paris on March 28, 1928.

The transmitting stations for the direct circuit are at Lawrenceville, N. J., and Pontoise, France, while the receiving centers are at Netcong, N. J., and Noiseau, France. The circuit between New York and Paris totals about 3,600 miles in length. The cost of a three-minute conversation between the two cities is $21 on week-days and $15 at night and on Sundays.

It is interesting to recall that it was in Paris that the first spoken words to be transmitted by radio across the Atlantic were heard. In 1915, through the courtesy of the French Government, Bell System engineers were permitted to set up receiving apparatus in the Eiffel Tower, in an attempt to pick up speech sent out by other telephone engineers from Arlington, Va. These experiments, ending successfully with the trans-

mission of intelligible speech, marked an important milestone in the development of the radio telephone system which now enable the Bell System subscriber to reach about ninety-three per cent of the world's telephones.

LARGEST WIRE HOOK–UP EVER ESTABLISHED UNITES MANY PIONEER GROUPS

PRESIDENT Walter S. Gifford of the American Telephone and Telegraph Company was the principal speaker at the international celebration of the Twenty-fifth Anniversary of the Telephone Pioneers of America, held on November 19. Over the largest wire hook-up ever established, Mr. Gifford addressed about 40,000 telephone people, gathered in 268 meetings in 234 cities in this country and Canada. The telephone hook-up extended from St. John, New Brunswick, to San Diego, Calif., and from Miami, Fla., to Edmonton, Alberta. More than 25,000 miles of telephone wires linked together the various groups, all of whom listened to the same speeches and heard the same entertainment.

Mr. Gifford was introduced to his vast audience by Chester I. Barnard, head of the international body of Pioneers and President of the New Jersey Bell Telephone Company, who was attending a meeting of the G. H. McCully Chapter of the Pioneers in Newark. From a meeting at the Hotel Commodore in New York of the Edward J. Hall Chapter of the Pioneers, of which he is a member, Mr. Gifford addressed his fellow Pioneers gathered in groups throughout the North American Continent. The international hook-up was introduced by President Barnard. Others who spoke were J. E. Macpherson, Senior Vice President of the Pioneers and Vice President of the Bell Telephone Company of Canada, who spoke from St. John, New Brunswick; and James L. Kilpatrick, President of the New York Telephone Company and President-elect of the Pioneers, who spoke from a meeting of the Empire Chapter at the Hotel Astor in New York.